Distal and proximal attentional focus effects on the performance of closed and open continuous motor skills.

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Abstract

Attentional focus research has reliably demonstrated that an external (beyond the body) focus is superior in terms of skill performance, retention and transfer relative to an internal conscious focus on movement mechanics. This thesis extends current knowledge by evaluating the impact of external focus distance on the performance of continuous skills in an applied context. Specifically, two external focus points of different distances were compared to an undirected attention condition. Three separate studies were conducted using different kayak sprinting disciplines; two of these took place in benign environments using relatively closed skills whilst the third was carried out in an open skill context. In all cases a within-participants experimental design was employed with an independent variable of conscious focus and a dependent variable of performance time.

In Study 1, using competent, experienced kayakers (n = 20) in a surf ski sprinting task, the distal external condition significantly outperformed both the undirected focus and proximal external conditions ($p < .001$ in both cases). The undirected focus condition was significantly faster than the proximal external focus condition ($p = .003$). The effect size was large ($\eta_p^2 = .55$). Study 2 examined the same attentional points using youth racers in K1 sprint kayaks (n = 16). The undirected focus condition was significantly faster than the proximal external condition ($p = .028$); the effect size was large ($\eta_p^2 = .23$). In Study 3 experienced kayakers (n = 27) were tested in a wild water racing task against the same experimental conditions. The distal external focus condition

significantly surpassed both the proximal external condition and the undirected focus condition (p < .001 in both cases). The effect size was large (η_p^2 = .53).

The studies in this thesis show that the distance of a specified external focus is important and can have a significant influence on performance. In contrast to previous work the proximal external focus did not provide a performance advantage relative to an undirected focus condition; in studies 1 and 2 it was actually detrimental. A distal external focus was beneficial compared to both other conditions in two studies and insignificantly different to the undirected focus trial in Study 2. This thesis brings together work on focus distance and skill type in three applied and non-contrived sporting contexts. The main practical implication of this research is that distance of focus should be considered by learners and coaches with a view to optimising conscious attention. A distal external focus appears to be particularly useful in targeting attention on a pertinent point whilst simultaneously excluding cognitive competition, distractions and unnecessary attentional switching which could undermine skilled performance.

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Thesis Declaration

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(a) that the thesis has been composed by me, and

(b) either that the work is my own, or, where I have been a member of a research group, that I have made a substantial contribution to the work, such contribution being clearly indicated, and

(c) that the work has not been submitted for any other degree or professional qualification except as specified.

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Chapter 1

Introduction

The inspiration for this thesis has been refined and developed through long personal engagement with the learning and teaching of physical skills. Seeking justification for a range of accepted and advocated approaches in skill acquisition has led me to a number of questions and investigations. In regard to this project specifically, motivation has been provided by an interest in the implications of conscious attentional focus in motor learning.

1.1 Delimitations, context and scope of the thesis

In over twenty five years of assisting others to acquire and develop physical skills, I have become well aware of the constant drive to focus learner attention on their body, equipment and immediate surroundings in the majority of formal teaching situations. This approach tends to be advocated either overtly by national governing organisations and various programmes of study, or incidentally as standard teaching and coaching approaches seem to lead inexorably to this behaviour (e.g. Porter *et al*., 2010a). It is questionable whether competent performers would typically focus in this manner, particularly if engaged in an open skill (in which there are variables in the performance environment either partially or totally beyond the performers' control), as it seemed they would usually have to concentrate on, and look at, the environment around them in order to make timely and appropriate decisions. An initial examination of the academic literature demonstrated that an internal focus on the body may, in fact, be detrimental to the acquisition of motor skills (e.g. Wulf *et al*., 1998; 1999; 2000); indeed, this led to me producing an article for the canoe coaching press highlighting my concerns (Banks, 2001a). This attentional focus question also formed the basis for my second Masters dissertation (Banks, 2009) and permitted the opportunity to understand the research field more thoroughly and to develop my coaching approach as a result. The experiment conducted in that study (using sea kayaking as a medium) suggested the likelihood of a benefit from an external focus in naturalistic settings in complex, continuous, open skills. This provided an effective pilot study on which to found the current academic venture.

My belief that the, apparently, pervasive approach of focusing learners' attention on their bodily movements and equipment may be detrimental to their motor learning, was suggested by my anecdotal experience as well as by a significant body of research (see Wulf, 2007a, 2007b and 2013 for comprehensive reviews). It originally led me to write an article (Banks, 2001) exhorting paddle-sports coaches to focus their learners' attention on where they are going rather than on their body, paddle or boat as is the norm. I claimed this 'Hard Look', as I termed it, would direct students' attention to the purpose of their manoeuvres and distract them from concentrating on the physical movements they had to make to achieve the outcome. I argued that this would create a more stable situation, as in looking in an effortful manner toward their goal, their head, arms, paddle and body orientation would automatically be more appropriate and would more likely organise the boat so as to be in the most advantageous position. Critically, directing their conscious attention towards the 'target' permits the paddler to subconsciously and dynamically self-organise and phase their movements, rather than trying to exert conscious control over their body and an unstable craft in a highly mobile medium.

The argument above was further based on long experience of a wide range of sports, and on watching how competent performers in virtually all disciplines lead their movements with their hands and head when being effective – the rest of the body and attached equipment following in a subconsciously self-regulated manner. This seems a sensible option if only to be aware of where you are travelling to, and of the factors in the environment which may constrain your performance, though the approach encouraged by many training organisations, teachers and coaches seems to reduce activities to their component parts and then ask their learners to concentrate on their bodies and defined physical movements in isolation. In searching for literature which would advocate or demonstrate the movement phasing which seems apparent in many sports skills (for example trampolining, throwing and jumping), I instead constantly found coaching advice which focused mainly or solely on the movement pattern, limb orientation and body position required (e.g. British Gymnastics Association[1]).

Whilst there are times when learners will need to be aware of their body position and to concentrate on appropriate physical movements, it seems that this approach may be dominant and is perhaps used at the expense of other

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[1] The British Gymnastics Association's website provides video coaching advice on a range of skills. The level and complexity of an internal focus on body and limb positions advocated is quite striking: http://www.british-gymnastics.org/bgtv/skills-and-tricks

important considerations. Furthermore, such heuristic facilitation may result in coaches and teachers condensing and compartmentalising activities into readily mimicked and highly tangible components which lead to them being more rapidly reproduced. This might then act to reinforce such an approach for learner and teacher alike. The potential problems with this approach seem to be that it demands conscious cognitive control of physical movement as well as a focus on the body rather than on outcomes. This appears to run the risk of constraining movement and might also be quite different to the method adopted by a competent performer. If such a difference exists there may also be a concern that, under future pressure, performers may regress to an earlier learnt focus which may not necessarily be beneficial to them (e.g. Pijpers *et al.*, 2003; 2005). For example, a white water kayak novice who has been taught to turn in and out of the current on a river by focusing on their knee pressure and boat edge may regress to this point from a later competency in which they focus on where they are going. This appears unlikely to be as effective as the external focus on the target as it may compromise effective responses in a fast paced and extremely dynamic environment.

Further encouragement for this internalisation of focus may come from the educational notion that learners must pass through a 'cognitive stage' at the onset of learning a new skill, wherein they are required to consciously focus on and develop an understanding of all the elements of the skill being tackled (Fitts and Posner, 1967). Indeed, during my recent attendances at a British Canoe Union National Trainers' meeting and a United Kingdom Coaching Certificate

Level 3 Coach moderation meeting, we were explicitly instructed to 'map' Fitts' and Posner's Stages of Learning theory directly to the level of experience of any learners (or rather we were to pass this on via coach and leader training courses). The overtly stated encouragement was to compartmentalise complex skills into individual elements for novices so they could be better 'learnt'. A clear by-product of this approach seeming to be an even greater emphasis on internally focused, technique centred coaching. Research into interference effects (e.g. Schmidt and Wrisberg, 2008; Fairweather, 2000; Magill and Hall, 1990), as well as that in attentional focus effects, has demonstrated that a varied learning environment with an external conscious focus produces more retainable, transferable and adaptable skill. The link between Fitts and Posner's (1967) Stages of Learning model and coaching approaches is minimal in both cases; an emphasis on matching training regimes as closely as possible to applied environments and practice is apparent at all stages of learning.

As a large quantity of contemporary research in a wide range of skill acquisition situations has amply and rigorously demonstrated the positive impact of an external attentional focus (see Wulf, 2007a; 2007b; 2013 for comprehensive reviews); it is quite possible that by asking learners to concentrate on the orientation of their bodies and limbs whilst in a boat, their ability to become more skilful may actually be undermined. Whilst, intuitively, such an approach to coaching may appear correct to those engaging it and, quite possibly, to learners too, it may actually be a less natural method which distracts students from task relevant information, overloads their working memory and interferes with their body's ability to dynamically and sub-consciously self-organise.

1.2 Learning and teaching

It is possible to argue that the most effective learning – that which is best retained and most adaptable – takes place in environments where it is impossible or very difficult to break the activity down into its constituent segments. In addition to having to perform all necessary technical elements in a synthesised manner, such skills are usually acquired in the applied environment, meaning that participants have to also contend with decision making and timing as well as with any psychological and physical demands. This type of complete-activity learning may be challenging to accommodate in many educational contexts, perhaps for ideological reasons though also because of constraints on time and logistics, though it does seem more common outside of such formal situations – it could be seen as the way in which we naturally go about attempting to learn anything.

It seems reasonable to believe that most physical skill teachers and coaches will have the best interests of their learners and students at heart and will seek to assist them to make progress as quickly and efficiently as possible. Breaking activities and skills down into their discrete techniques might therefore seem a sensible and effective method of speeding up the learning process. Such an approach does have an important role, and may be beneficial if it saves learners from struggling with intricate elements which they cannot reasonably be expected to discover or work out in a timely manner (tying a knot appropriately whilst caving, climbing or sailing for example) or to protect them from harm or from ingraining inappropriate methods. In the drive to achieve technical proficiency goals however, a point may be reached where over-reduction leads to a lack of complexity and interconnectivity which might diminish the retention, adaptability and transferability of what is covered. This is not a new concern for academics and teachers; for example Higgins (2003) extolled and advocated the virtues of 'Keeping Learning Complex', whilst in the 1980s and 1990s the Teaching Games for Understanding (TGFU) approach to Physical Education, deliberately eschewed the 'technique first' approach (Bunker and Thorpe, 1982) in favour of a focus on tactics and decision making. Ironically, the mechanism frequently used to make whole-game situations accessible to students via TGFU was to modify the game and the equipment – sometimes to the point where the activity no longer resembled the normal form game (McMorris, 1998), this therefore may have also hindered transferability. McMorris also pointed out that the TGFU method was an approach to pedagogy rather than one driven by motor learning research. From an attentional focus viewpoint however, reducing the concentration on bodily movements and instead placing it on decisions and outcomes, would appear likely to result in enhanced performance and learning of what is being practised.

When activities are considered which we are able to return to after long periods of disassociation and yet which we are still able to perform perfectly well, we often state that it is 'just like riding a bike'. The clear inference being that riding a bicycle is a skill that is permanent no matter how long the period of inactivity between rides. Indeed, this is such a common saying that people may actually consider cycling to be some kind of special case in regards to learning, rather than questioning why it is that this skill is so well retained throughout their lives. What is it that we do as learners in this activity that makes it so retainable? On what do we focus our attention as cyclists? The answers to these questions may lie in the complete-activity nature of the learning and the requirement to concentrate on the surrounding environment whilst active. Whilst it is possible to acquire competence in the actions of pedalling and steering with support from a parental hand, stabilisers or a tricycle (and these activities also require engagement with the surroundings as well as multiple physical movements concurrently) true cycling only really begins once these props have been removed. At this point beginners have to learn to balance and to understand that stability and motion are inextricably linked. There must be a fusion of physical movement, confidence and decision making all of which must be developed simultaneously. The wholeness of the activity coupled to the trial and error approach most of us go through to reach competence, seems far more mentally engaging and leads to high levels of skill and memorability. Clearly, cycling is not the only skill which we are able to retain so effectively; many other skills which we engage with at length in a less tightly structured manner, seem also to be well remembered, highly adaptable and subconsciously controlled. Many of these we may not even consider to be skills at all, though all physical movements we use to an end have to be appropriately judged and timed to achieve a successful outcome – dashing through a busy station concourse whilst managing an awkward bag, avoiding collisions and searching for the appropriate platform requires a significant level of skill.

There are, however, formal learning environments which do demonstrate excellent long-term retention and very high levels of adaptability amongst virtually all learners. Again, these appear to be the ones in which the whole activity is attempted at once and in the fully applied environment. On the skill acquisition and motor learning courses which I run, I commonly ask the clients were I to ban them from driving or travelling in a car for an extended period of time whether or not they would still be able to drive at the end of that time. They universally answer 'Yes'. This unequivocal and unanimous response may seem unsurprising but consider the same question in relation to other skills which we are taught and coached throughout our lives. Even asking those who cannot yet drive, such as a group of sixteen year olds, whether they will be able to drive garners a very positive response - they are usually surprised that the question is necessary. Asking them the same question in relation to playing a wide variety of complex sports such as invasion games or an outdoor activity such as kayaking on white water produces a far less sure reply.

When we analyse driving as an activity it is rapidly apparent that it is a complex, open skill. Not only does the driver have to simultaneously manipulate multiple, diverse controls with both hands and feet to accurately control a very large, heavy and dangerous piece of machinery, they then have to manoeuvre the vehicle at speed in a highly variable environment. The driver has to take account of and contend with all the environmental and road conditions, other road users, pedestrians and signals – this is a prodigiously complex skill requiring split second timing and very accurate decision making. The consequences of an error are potentially very serious indeed, yet virtually everyone who is permitted to drive and can afford to do so is able to pass a driving test. How is such an incredible level of success possible when compared to the relatively low numbers of people working at such a skilful level in other disciplines? Why do so many people who can drive seem to consider themselves incapable or very poor at acquiring and performing other complex skills? Surely if they can learn to drive and are sufficiently motivated, they can also learn to be as competent in other challenging activities?

The critical differences appear to be the way in which driving instructors have to do their job. The often encountered, compartmentalised approach is not possible because very early in the learning process the student has to contend with the whole vehicle in the real motoring environment – the instructor cannot say “Today we’ll do steering and tomorrow we’ll cover gears and, on Friday, we’ll look at braking”. To suggest such a method appears ludicrous - as well as extremely dangerous – but this is precisely the approach coaches and teachers may adopt when it is possible to do so. Driving tuition cannot take account of individual learning preferences, everyone has to cope with a holistic method with support from an instructor whether they like it or not. Likewise, an appropriate, external focus of attention is strongly encouraged by virtue of the fact that the training takes place, in the main, on the road and in the traffic – an internal attentional focus on bodily movement might rapidly be punished if the driver does not respond to the environmental cues around them. Such a conscious focus on the body would, according to the attentional focus research (e.g. Lohse and Sherwood, 2012; Mullen *et al*., 2012, Wulf and Lewthwaite, 2010) also result in poorer motor control. The desire to work on individual elements of the skill in isolation to match with a 'cognitive stage of learning' also cannot be achieved. Instead, a holistic method working towards the development of subconscious control as rapidly as possible is deployed (perhaps unwittingly) by instructors. This process takes, on average, six months of formal lessons and intermittent practise[2] before a test is passed though, whilst this may appear a long time, when the level of skill that has been acquired is considered, along with the retainability and transferability achieved; this is a truly impressive feat.

Whilst a 'building block' approach to coaching might demonstrate relatively rapid reproduction of individual techniques in the short term, it may not provide a quicker route to being as skilled as a driver or cyclist. In fact, the initial focus on reproducing isolated techniques may actually hinder the development of subconsciously controlled skills as they are often manipulated and altered in order to work out of context. Whilst this technique centred process may generate higher initial levels of learner and coach satisfaction and

[2] The Driving Standards Agency report the average amount of training and practise time to pass a test is 45 hours of professional training and 22 hours of private practise, though the time taken increases markedly with age. http://www.theaa.com/aattitude/start-learning/getting-ready/about-the-practical-test.jsp

apparent success, the true measure of learning and skill is not whether the individual elements can be repeated immediately, it is whether they can be synthesised, retained and utilised in the long term in an automatic manner – the whole being greater than the sum of the parts. In order to achieve this, learners need to be able to appropriately apply the technical, tactical, psychological and physical elements of the activity in its normal environments. The role of the coach should arguably be to support learners in such a context, providing safety, discussion, tasks and information as needed whilst trying to maximise the activity time and the learners' engagement with the process. Driving and cycling provide excellent examples of how effective our skill acquisition can be both in formal and informal learning situations whatever our abilities. They also demonstrate how different the coaching approaches to physical skill acquisition may be in formal (and informal) learning settings and, specifically, suggest it may be inappropriate to focus learners' attention on their bodies and equipment – especially in an open skill activity. It would further appear that in most areas of learning, coaching and education (particularly with novices) we intuitively believe that we must provide an internal, conscious focus on isolated techniques in an uncluttered context. As Wulf (2007a) points out:

> "*... the traditional belief is that learning during the early stages is enhanced when learners are made aware of their movements and of how they are performing in relation to the goal movement. To facilitate the learning process, instructions and feedback are typically given that direct learners' attention to various aspects of their movement coordination.*"
> Wulf (2007a, p.7)

Attentional focus research is adding to the body of evidence which supports a less technique-driven approach to physical skill learning by demonstrating the effectiveness of an external, compared to an internal, focus on movement mechanics. This does not mean coaching and teaching cannot be well-organised - or even defined in advance; rather it indicates an in-depth understanding of technique may not be critical for a student, particularly a beginner, and such technical guidance might be better reserved for times when the learner needs such input because they have reached an impasse. This may alter the skill training and learning process from one in which theoretical and technical information is frontloaded and consciously concentrated on as some kind of foundation, to one which is based on the needs of students and performers as they stretch their limits and seek to reach their potential. Whole-population learning of complex skills such as driving and cycling provides evidence that high levels of declarative knowledge may be unnecessary. Whilst it is vital coaches are able to accurately and effectively evaluate their charges, such analyses might, perhaps, be translated into activity which matches teaching environment and practise to intended application as closely as possible. Maintaining an external focus of attention in motor skill learning may have a significant role, and might enable coaches and teachers to provide effective practise keeping the 'What's the point?' question at the forefront of their mind.

It would seem from an overview of the attentional focus research that encouraging learners to consciously concentrate on the outcomes and effects of their actions, as opposed to the motor movements creating them, may lead to enhanced retention, adaptability and transferability of learning i.e. they may become genuinely skilful 'just like riding a bike'. The current evidence from a wide range of skills and activities, assessed in both laboratory and applied studies (see Wulf, 2007a; Wulf, 2007b; Wulf, 2013 for fulsome reviews), clearly suggests the likelihood of this. Real life appears to demonstrate it all the time – we should, perhaps, pay more attention.

1.3 Aim and objectives of the thesis

On the basis of the above commentary, prior academic study and the research evidence gleaned thus far, a formal literature review and series of controlled experiments will seek to examine the impact of attentional focus in skill acquisition. In particular, an extension of the current research to examine different external focal points will be considered in applied sporting contexts. Specifically, this thesis will concentrate on the following aim and objectives:

1.3.1 Aim

To examine the effect and interrelationship of proximal and distal conscious attentional focal points on skilled performance. Whilst the intention is to produce generalisable findings, in order to delimit the scope of the investigation, the skill type and activity family will need to be restricted.

1.3.2 Objectives

- Discuss current approaches to skill acquisition and motor learning and relate personal experience to these to identify a valid research question.

- Develop a thorough understanding of the relevant literature and report this in relation to the identified research question.
- Systematically examine various methodological approaches to gain personal understanding and to enable the selection of appropriate methods for subsequent research experiments.
- Construct and conduct valid studies which extend current research and which produce data that can be meaningfully analysed.
- Develop an understanding of pertinent statistical methods and apply them appropriately.
- Report and critique research findings and identify implications for practice.

1.4 An overview of the thesis

Following the identification of an area of interest to explore, the initial phase of this thesis will concentrate on an extensive and critical review of the pertinent literature. This will be compared to current prevalent approaches both generally and specifically in regard to the activities used in the subsequent studies. This process will lead to a second phase including the formulation of specific research questions and a methodology section to examine how they can best be approached. This examination and intervention element will require individual studies to be conducted and reported separately with results, statistical analysis and discussion. Following this an overarching discussion will be provided along with research implications, suggestions for future work and concluding comments.

Chapter 2

Literature Review

2.1 Introduction

The past fifteen years have seen a surge in interest in the effect of an individual's focus of attention on both performance and learning. This field has now developed to a point whereby a wide range of situations have been experimentally examined and explanations posited for the effects encountered. Research and comprehension continues to be developed as new avenues for investigation into attentional focus effects become apparent and gaps in knowledge and understanding are addressed.

This literature review traces the origins of enquiry into conscious attentional focus, reports the critical elements and associated research as well as eliciting potentially beneficial findings and their application to real-world situations. It also seeks to establish the veracity of claims made and examines the validity and relevance of the research to date. The various, individual research and evidence strands have been gathered and considered to build a whole 'picture' of the subject area. Specifically, a cross-section of historical perspectives on attentional focus effects is followed by definitions of critical terms used in the thesis. Theoretical stances in regard to attentional focus effects are presented; reference is then made to psychology, neurology and physiology to provide underpinning evidence. Following this, findings from laboratory and applied studies into attentional focus are reviewed before the research conducted to date is summarised.

2.2 History

> *"It would seem indeed that we fail of accuracy and certainty in our attainment of the end whenever we are preoccupied with much ideal consciousness of the means ... keep your eye on the place aimed at, and your hand will fetch it; think of your hand, and you will very likely miss your aim."* (William James, 1890, p.520)

In his seminal 1890 work 'The Principles of Psychology: Volume 2.' William James argued that 'the less tactile, muscular and resident our consciousness' the more effective we will be (in a physical task). He believed a more 'remote' point of thought to be superior in such situations, as his comment above demonstrates. The field of attentional focus research, in a significant academic sense, is relatively recent though the notion that learners' focus may be an important contributor to their performance had not escaped James or other earlier writers and academics. As long ago as 1893 Bliss also highlighted concerns regarding the potentially negative effects of 'providing explicit information to aid implicit learning'; writing about his experiments in his 'Investigations in Reaction-Time and Attention' he comments:

> "*... the attempt to shorten the reaction time by turning the attention toward the hand or the movement to be made was a decided failure*." (Bliss, 1893, p.38)

Boder (1935) later confirmed this issue finding that such externally provided instructions detrimentally affected physical skill acquisition. More recently, writers such as Gallwey (1974) and Gallwey and Kriegel (1977) have argued that reducing conscious control of the body and allowing subconscious processes to direct movements would lead to far more effective performance.

In their 'Inner Game' books they based this on the notion of the left and right hemispheres of the brain being responsible for conscious and subconscious mechanisms respectively, thus they advocated a 'right brain' approach to learning and performance. Whilst the concept of phenotypic differences between brain hemispheres has not been supported by research (see Neilson *et al*., 2013; Leevers, 2014), in a more scientific manner, this concept has been described as associative, in which bodily sensations are focused on, or dissociative in which they are deliberately blocked out (Morgan, 1978; Weinberg *et al.*, 1984).

Some researchers commented on the disruptive nature of conscious control on motor performance (e.g. Schneider and Fisk, 1983; Green and Flowers, 1991) whilst others highlighted that further aspects of human learning are also dislocated when conscious control is deployed: Reber (1976) studied cognitive learning and discovered that the effectiveness of autonomous mechanisms was undermined when conscious manipulation was attempted. In effect, these writers argued that subconscious memory functions are overridden by conscious, cognitive control. Kimble and Perlmuter (1970) commented that:

> *"the act of paying attention to .... performances or describing the steps as they occur tends to destroy the automaticity of such behaviour"* (Kimble and Perlmuter, 1970, p.375)

Questioning the effectiveness of requiring learners to be consciously aware of their bodily movements, Robert Singer, a professor of psychology at the

University of Florida, claimed such an approach to be futile in aiding the execution of skills. Singer (1985, 1988) and Singer *et al.* (1991, 1993) argued instead for an approach which distracts learners from such explicit control believing that this would lead to a state of subconsciously organised movement. He developed his Five-Step Approach to include strategies which either made the learner aware, or kept them unaware, of their own body. These steps were 1) to encourage the learner into a positive emotional state, 2) to mentally rehearse the motion, 3) to concentrate on a single pertinent cue or factor, 4) to complete the action without considering either the movement or potential result and 5) to evaluate the outcome and to make adjustments before further attempts. Whilst this method does require that the performer has time available to go through the stages, which is only going to be the case in self-paced skills, it was an early attempt to challenge an approach to learning which relies on the provision of explicit information directing learners to their own bodily movements.

The limited applicability of Singer's method stimulated other researchers to suggest a more radical approach whereby information provided to learners would be reduced to an absolute minimum (e.g. Masters, 1992). Masters was concerned that in supplying instructions to performers they are likely to overly concentrate on how they are executing the movement. He argued that this information 'reinvestment' would be detrimental to being skilful. Instead, he and colleagues (Masters *et al.*, 1993) proposed that learners be allowed to develop skilled behaviour subconsciously so that automatic control of movement is not hampered by conscious processing. The difference between this approach and that put forward by Singer (1985, 1988), is that Singer advocated thinking about movement patterns before and after (though not during) activity whereas Masters (1992) argued that such thought processes are harmful in general and should be avoided at any stage of the learning process. Masters (2000) contends that implicit skill learning confers benefits such as resilience to skill failure under pressure, though does also state that it may not provide durability in dual task situations.

In 1996 whilst attempting to learn to gybe[3] on a windsurfer, Gabriele Wulf was struck by the ineffectiveness of instructions from coaches and manuals which directed her attention to her bodily movements in great detail in a step-by-step fashion. On later attempting to gybe without recourse to such assistance she found that, whilst far from perfect, she was considerably more successful when concentrating on the movement outcome rather than the movement itself:

> *"... when I focused my attention on the effect that I was trying to achieve with these movements, namely the effects of my movements on the surfboard, my performance was suddenly much better. This experience was most impressive!"* (Wulf, 2007a, p.36)

This encounter with the impact of an altered attentional focus led Wulf to question whether such an effect would be generalised across all learners and in

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[3] A gybe is a sailing manoeuvre whereby the craft turns its stern through the oncoming wind so that the wind passes from one side of the stern to the other. During this turn the sail (or sails) also change sides. The more common manoeuvre would be to 'tack' the craft, i.e. turn the bow through the wind – 'going about' in this manner is typically more controlled and less violent than gybing.

all learning situations. It has stimulated her to make this field the 'cornerstone' of her academic career to date and to the production of and collaboration in a very large number of studies into a great many aspects of attentional focus in skilled performance. This in turn has encouraged others to research in this area and has provided the stimulus for this thesis.

2.3 Definitions

When discussing aspects of learning, coaching and performance several terms are used frequently and in this context have well accepted specific meanings. As some of these words are also used in common parlance and do not have such limited usage, or are used interchangeably, it is worth identifying these critical definitions at the outset. In the field of skill acquisition and motor learning some of the most commonly used terms are technique, skill, performance, learning, retention and transfer.

Technique: In a motor learning sense techniques are the physical movement patterns associated with any given activity. This is context free in that these movements are usually considered in isolation and often assessed against a measure of biomechanical accuracy or perfection rather than their interaction with the environment. I tend to describe to my own students the notion of having (good) technique as 'the ability to reproduce a fixed action pattern'. Whilst this refers to physical movements here, it could also be used in a parallel fashion in other types of activities: for example, the ability to correctly inflect and replicate verb conjugations during second language learning may signify a high level of grammatical technique though does not necessarily confer any additional ability on the part of the 'performer' to be able to deploy the correct verb at an appropriate time in communication.

Skill: The critical difference between skill and technique is that skill relates to using the technique in the environment for which it is intended and so would be described as 'the appropriate application of technique'. Magill (2011, p.5) believes skill to be 'an activity or task that has a specific purpose or goal to achieve.' It is therefore very possible for an individual to be taught or to learn techniques to a high degree of reproducibility but to have little or no skill whatsoever. Conversely, individuals may be able to cope in a real-life situation such as a game (i.e. be skilful to a degree) though have underdeveloped technique. High skill levels are typically associated with accurate, consistent and reliable performance output, i.e. effective movement; as well as movement which requires relatively low levels of physical and mental effort, i.e. efficient movement. Both of these critical aspects are measured by researchers.

Skills can be classified on continuums in several ways (Schmidt and Wrisberg, 2008, p.4-8); the most common, and the ones referred to in this thesis, are open – closed; discrete – serial – continuous; and fine – gross. Open skills are ones in which there are variables in the performance environment which are either partially or totally beyond the performer's control. As a skill moves along the continuum towards 'closed' then these variables are likely to diminish in number, though more importantly, in their variability. Typical variables would be weather, terrain, surface mobility and other people (e.g. opponents, team mates, officials, spectators, participants). The faster the pace of change (variability) and the more directly the variables affect the performer (e.g. physically as in rugby), the greater the 'openness' of the activity. Open skills are also called externally paced skills due to the high levels of responsiveness and adaptability required. Closed skills are often referred to as self-paced due to time pressure decreasing as the impact of variables diminishes. Discrete skills are ones with a defined beginning and end – a one-off action which can be either simple or more complex - such as a kayak roll. Serial skills are linked discrete skills so can be subdivided into their component parts; the triple jump is an excellent example. Continuous skills are ones with a cyclical action such as swimming, running, cycling and cross country skiing; the more unwaveringly repetitive the action the more closed the skill is also likely to be. Finally, gross motor skills (e.g. shot putt) utilise large and powerful muscle groups such as the legs, abdomen and torso whereas fine skills, such as playing the piano, require accurate and dextrous use of small muscle groups as in the hands and fingers.

Performance: In skill acquisition research this is one of the most commonly assessed factors and is clearly of great interest to most participants – particularly competitors. Performance relates to an individual's or group's measureable physical output; researchers study the immediate impact of a given factor or condition on performance and differentiate this from an appraisal over the longer term. It is normally assessed by quantifiable, mechanical means though occasionally by expert markers using pre-determined assessment criteria. Common measures would be time, distance, speed, height, force, accuracy and score. Comparisons can be made between different trial conditions as well as against no-condition 'benchmarks' (controls) so that both positive and detrimental effects can be ascertained. The point in research at which performance is examined is often referred to as the 'training' phase or 'skill acquisition' phase.

Learning and Retention: When the term 'learning' is used in motor learning it refers to the measureable output as opposed to the process. Learning indicates an enduring effect, it was described by Schmidt and Lee (2005, p.303) as a 'relatively permanent change in a person's capability to perform a certain skill'; it is usually determined over a fixed period of time and calculated as the amount of performance which has been retained once the temporary effects of any practise or activity have had a chance to dissipate. This usually means that an interval of at least a day is provided before applying a retention test (in which no instructions or information are provided) though often many more. Retention is therefore a critical gauge of the effect of any given manipulation as short term impacts on performance, whilst useful and potentially impressive, are often of less benefit to learners than ones which persist over time.

Transfer: As well as being able to assess the immediate and long term effects of any given variable it is also important to be able to calculate how robust such performance and learning is under different circumstances. Scientists therefore seek to measure a learner's adaptability by presenting them with situations in which the skill has to be performed in an altered or different context or in a different manner. This transferability of skill can then be measured and the impact of different factors on transfer can be compared. This is of particular value for skills which are deployed in an externally paced environment and, as Fairweather, (2000, p.115) highlights, the ability to adapt skills and learning to a range of different activities and to situations other than the training environment is vital.

Attentional Focus: This term is clearly central to this whole work and, as such, requires some clarification. Crucially, it is important to note that in this field of research 'attentional focus' relates only to the aspect or element of performance which is consciously, cognitively considered whilst active. This is differentiated from visual attention and gaze and is also distinct from any other sensory attention as it is quite possible that, under normal circumstances, attending to a particular cue will require the use of any one, or a combination, of the body's sensory capabilities. In relation to attentional focus research specifically, McNevin *et al.* (2003) define the difference between an internal and external focus of attention as:

> *"... directing performers' attention to the effects of their movements ("external focus"), rather than to the body movements producing the effect ("internal focus")."* (McNevin *et al*., 2003, p.22)

Academics involved in studying these effects consequently often seek to control sensory input (vision most commonly) so as to isolate and make measurable any impact of conscious thoughts.

It is also worth explaining at this point that attention has been examined from a range of perspectives including, for example, associative or dissociative (focusing on or blocking out sensations resulting from physical effort), width (broad or narrow) and sensory attention such as visual. This thesis will concentrate on the impact of an internal and external conscious focus of attention though may refer to parallel findings from other areas and strands. Further clarification of terminology will be provided on an ongoing basis as required in the text as the work progresses.

2.4 Theoretical Basis

The potentially negative effect of attempting to consciously control one's own physical movements has, in recent years, been thoroughly researched e.g. Bell and Hardy, (2009); Lohse, (2012); Marchant *et al.*, (2011). The majority of research evidence (see Wulf 2007a, 2007b, 2013 for comprehensive reviews) indicates that when a performer or learner consciously contemplates their physical movements during activity, this confers no advantage compared to having no specific focus. In some cases such an internal focus has actually been found to be relatively detrimental to performance and learning when evaluated against a no-focus control e.g. Beilock *et al.,* (2004); Poolton *et al.,* (2006) and Vuillerme and Nafati (2007). In contrast, when the focus is shifted to an external point (via instructions or feedback), usually one very close to the participant, this nearly always bestows a significant advantage on both performance and retention (learning) in relation to an internal and no-focus condition (e.g. Shea and Wulf, 1999; Lohse *et al*., 2010). This, apparently, counterintuitive finding appears to be a robust phenomenon which has a demonstrably beneficial impact on movement effectiveness (e.g. Marchant *et al*., 2007) as well as movement efficiency (e.g. Schücker *et al*., 2009) and, as such, has caused those involved with this line of work to theorise as to why the effect exists.

2.4.1 Common Coding Theory

Once the effects of differentiating between attentional focus points had become apparent, reference was first made to Wolfgang Prinz's (1990, 1997) Common Coding Theory in the search for an explanation (e.g. Wulf and Prinz, 2001). This theory claims that there is a common brain representation (code) of actions in relation to the perceived (external) effects they produce. Prinz believed that performing a movement creates an association between the generated motor pattern and the sensory output generated. This link can then be utilised to retrieve a movement pattern by anticipating its effects. It does though, also predict that there is a shared neural system for both action and perception and that when these two functions attempt to access this 'structure' simultaneously (e.g. whilst using an internal focus) that interference will occur.

A range of motor cognition studies have provided support for this theory including that of Decety and Grèzes (2006) whose functional magnetic resonance imaging (fMRI) experiments suggested that the neural circuits involved in the execution of actions partly coincide with those stimulated when actions are observed – watching the action may activate the same brain areas as performing the action. Therefore, when it was discovered that performance and retention were improved with a focus on the movement effect, this seemed to align with the predictions and assumptions of Prinz's theory, i.e. in avoiding the interference caused by concurrent usage of the same neural pathways more effective and efficient performance results. As Wulf (2013, p.91) points out however, Common Coding Theory does not aid in the identification of internal and external focus effects nor does it assist in providing an explanation as to why they occur.

2.4.2. Control Based Learning Theory

Willingham (1998) advanced his Control Based Learning Theory of motor control (COBALT) to address the elusive nature of the neural mechanisms involved. He advocated that we have three motor control processes which are dedicated to specific tasks: selecting spatial tasks for movement, prioritising and ordering the movements and transforming them into motor commands. To these functions Willingham added a further consciously controlled function which, he argued, could operate in two distinct ways: by choosing more effective movement tasks and by sequencing those tasks more appropriately. Whilst the three initial functions are deemed to be implicit, i.e. subconsciously controlled, only the final one must always be so, as it is possible to override the first two functions by using the explicit control mechanism. Use of the implicit (automatic) control mode is expected to be faster and, whilst it is postulated that explicit control may be useful in the learning of a novel skill, it is also anticipated that conscious organisation of movement may disrupt skilled performance.

COBALT therefore provides a process based explanation of neuro-motor control which, when applied to attentional focus, would explain external focus superiority over an internal focus by claiming that the former does not hinder implicit motor control processes. One way in which this may be assessed is by measuring the time taken between attempts at a motor task under different attentional conditions – an external focus would be predicted to speed this process relative to internal attention as it does not interfere with subconscious movement selection and sequencing. This theory is not without its supporters and attentional focus research is sometimes conducted and explained in relation to it, e.g. Lohse *et al.,* (2010), Beilock *et al.*, (2004) and Lohse (2012). Proponents argue that it provides a thorough, cognitive explanation of motor control processes. It does though appear that if this hypothesis is correct then an explicit (conscious, internal) focus should cause an internal focus disadvantage in relation to a no-focus control situation. Some researchers have reported this outcome (e.g. Beilock and Carr, 2001; Beilock *et al.*, 2002). Furthermore, Beilock and Carr (2001) proposed an explicit monitoring hypothesis that accounts for the differential effects of attentional focus on novices and experts (e.g. Beilock *et al*., 2002) by claiming a need to attend to and process the individual skill components early in learning though not once the skill is proceduralised. Wulf's (2013) review of attentional focus research, in which she tabulates relevant studies with their findings, indicates that most work does not indicate significant[4] differences between populations. Instead, they typically report an external focus advantage in relation to internal and control conditions. This would indicate that our natural implicit control mechanisms can be enhanced with a directed external focus though this does not seem to fit with COBALT or an explicit monitoring explanation.

2.4.3. Constrained Action Hypothesis

As a result of the perceived limitations of Common Coding Theory, Wulf and her colleagues (Wulf *et al.*, 2001) proposed the Constrained Action Hypothesis as a verifiable rationale. This is based on the notion that the body tends to adopt dynamical and subconscious control whenever possible and that by consciously trying to control these systems (internal focus) such actions are constrained, slowed and made less effective and efficient (Facoetti and Molteni, 2000). In contrast, when an external focus is adopted these normal, automatic processes are not only unhindered, they may also be promoted due to the more appropriate and limited focus deployed. This, it is thought, leads to faster, more reflexive responses which result in reduced demands on attentional capacity (e.g. Wulf *et al*., 2001), reduced response times (e.g. Lohse, 2012) and improved

[4] Whenever the term 'significant' is used in this review in relation to academic studies or research it indicates a statistical significance with a probability value equal to or less than .05 ($p \leq .05$).

Fast Fourier Transform (high frequency movement adjustments) (e.g. McNevin *et al.*, 2003).

The Constrained Action Hypothesis supports the notion that performance and learning are enhanced as a result of reduced conscious interference in cognitive processes that are already automatically controlled. Over the space of our lives we establish highly developed neural pathways which permit us to control our movements in a subliminal manner. It also appears that we are able to use such conduits to assist us with a range of related and even new tasks as we bring to bear a lifetime's worth of kinaesthetic and proprioceptive development to assist us. For example, it would come as no surprise that a specialist white water kayaker would be able to quickly adapt to the different craft and conditions presented by sea kayaking with little or no assistance.

Whilst the Constrained Action Hypothesis seems a more coherent explanation of the relative effects of different attentional focuses, it does not in itself provide an indication as to the underlying neural mechanisms involved. With this in mind Wulf and Lewthwaite (2010) proposed an extension to include the notion that an internal focus produces, what they term, 'a *self* invoking trigger'. This is based on the apparent propensity of even the smallest reference to one's body parts or movements to enable or cause access to the neural representation of the 'self' (e.g. Bargh and Mosella, 2008). In turn, this is thought to result in the self-evaluation of thoughts, actions and behaviour leading to what Wulf and Lewthwaite call 'micro-choking episodes' and an associated degradation of output. Whether attempts to consciously control physical movements are a precursor to sub-optimal performance or, alternatively, whether even simple references to the body lead to thoughts of the 'self' which are detrimental to effective functioning, it appears further studies are needed to ascertain the interaction between focus and outcome.

2.4.4 A motor programme versus a dynamical systems theory view

Whilst attentional focus research is typically explained using the aforementioned conceptual frameworks (Prinz, 1997; Willingham, 1998; Beilock and Carr, 2001; Wulf *et al*., 2001; Wulf and Lewthwaite, 2010), it is also worth assessing how the results of such studies fit with more general theoretical positions on motor learning and control; there are two schools of thought that predominate in this regard. Based on the concept of schemas, in 1975 Schmidt published his theory of generalised motor programmes in which he claimed such programmes (classes of actions such as running, kicking, throwing, cycling) have a common though unique set of movement related invariant properties. Whilst these characteristics do not alter between performances of any given action there are theorised to be parameters within which variability exists such as the relative order, force, speed and timing of the movement (Magill, 2011, p.92). Schmidt argues that the flexibility provided by these parameters (which he called motor response schemas) permits adaptation to novel situations, even those not previously encountered, so that the skill can be performed effectively. This additional or new experience is then added to the generalised motor programme.

From an attentional focus viewpoint, it could be argued that conscious control of movement mechanics may reduce degrees of movement freedom and constrain the subconscious, memory-based control processes which Schmidt proposes. Conversely, an external focus may allow motor response schemas to adapt automatically so that performers improve relative to an internal focus condition as would be predicted by the Constrained Action Hypothesis. This may also be seen to parallel the findings from interference research (see Magill and Hall, 1990) which has repeatedly demonstrated that variability of practise both within and across generalised motor programmes enhances learning and adaptability of skill, whilst repetitive practise of a fixed action pattern tends to produce better initial reproducibility of the movement (e.g. Lai and Shea, 1999; Lai *et al*., 2000; Whitacre and Shea, 2002). This in turn could be viewed as the difference between creating effective motor response schemas (parameters) as opposed to robust generalised motor programmes. It is arguably the case that in blocked practise situations conscious attention may be focused more frequently on internal movement mechanics than when task related factors draw conscious focus to external points. Whilst the majority of attentional focus studies have demonstrated a directed external focus benefit (see Wulf, 2013, for lists of research conducted up to 2012), they have also tended to be conducted in relatively simple laboratory tasks or discrete applied skills (e.g. McNevin *et al*., 2003; Poolton *et al*., 2006; Jackson and Holmes, 2011; Lohse and Sherwood, 2012). A criticism of the motor programme framework is that as skills become more complex then increasing numbers of generalised motor programmes are required to cope with the array of movement patterns and classes of action required. The storage and manipulation issue this may create is seen as a weakness of this theory (Schmidt and Wrisberg, 2008, p.123). It would therefore be informative to assess whether the same external focus benefits exist in more complex skill situations and if a motor programme explanation provides the best fit with the findings.

The second and alternative dominant motor control framework which has been advocated is dynamical systems theory; this arose as a solution to Bernstein's (1967) 'degrees of freedom' problem i.e. how can the many ways in which the motor system move be controlled and co-ordinated to produce effective action. Researchers such as Kelso (1997) and Newell (2003) have questioned the viability of Schmidt's theoretical assumptions and believe an explanation based in non-linear dynamics may better attend to the issues of memory storage and adaptable motor control in complex movement environments. Proponents of this theory argue that our bodies dynamically adjust from a stable state to a different stable state in response to environmental factors and the demands of the skill. Magill (2011, p.96) points out that such changes do not occur in a gradual manner and instead may be abrupt, i.e. a linear change in the demands on the performer may create a non-linear change in their performance. This has been demonstrated in experiments in which the speed of movement is gradually increased to the point where the type of movement suddenly changes e.g. Kelso and Scholz, 1985, Scholz and Kelso, 1990, synchronised finger movements; Seifert *et al.*, 2004, swimming; Diedrich and Warren, 1998, walk to run gait. Dynamical systems theory also overcomes the memory capacity issue of having huge numbers of motor programmes, particularly in complex activities, by using the concept of 'synergies'. Saltzman and Munhall (1992) describe these as

> *"… a temporarily and flexibly assembled functional organization that is defined over a group of muscles and joints and that converts those components into a task-specific, coherent multiple-degrees-of-freedom ensemble."* Saltzman and Munhall, 1992, p.50.

Therefore, instead of movement patterns being pre-programmed in advance and deployed automatically as would be argued by Schmidt, they are thought to emerge as a function of environmental, task, and personal limitations (Handford *et al*., 1997). In effect, rather than having fixed motor programmes on which to draw (which require large amounts of memory), we are able to create 'synergies' to cope with situations as and when needed.

The potential benefit of assessing attentional focus findings through the dynamical systems 'lens' may become apparent when more complex skills are studied, particularly those in an open skill context, and also when the abrupt alterations seen in physiological studies under different focuses are considered (e.g. Lohse and Sherwood, 2012; Vance *et al*., 2004). In these situations the notion of motor programmes may lose its appeal due to the increasing number required to permit skilful movement and the lack of gradual physiological change under different focus conditions respectively. The dynamical systems approach would arguably overcome these problems and may further be deployed to assist in explaining the benefits associated with an external focus, particularly if this promotes a more effective engagement with appropriate cues in the performance environment.

Whilst the two motor control positions described here continue to be the subject of academic debate (e.g. Magill, 2011), attentional focus research would seem to propose in addition that the motor system has the capacity to *somehow* produce coordinated, efficient behavior, provided the performer lets the system control itself by consciously focusing on the intended movement effect or goal rather than on bodily movement.

Section 2.4 Summary

Attentional focus is a field of research with plenty of scope for development; it is therefore unsurprising that there is no universally accepted explanation for the conscious focus effects reported in the motor learning and psychological literature. Motor control theories sit beside cognitive processing rationales; this demonstrates perhaps, that in time, a 'grand unified theory' may be arrived at. Despite the lack of complete agreement, the Constrained Action Hypothesis (Wulf *et al*., 2001; Wulf and Lewthwaite, 2010) appears to be the most widely cited theory of the conscious attentional focus effects repeatedly observed across a wide range of studies. At a more general motor learning level, advocates of the dynamical systems explanation argue that they can provide a more effective match with the results seen in applied attentional focus research (especially in more complex skills) where the number of motor programmes required to be skilful may be a constraining factor in its own right. Proponents of a dynamic systems approach may also point to the interaction with the environment which an external focus generates; they may see this as support for the argument that a critical dynamic interaction exists between environmental cues, the task and the performer's nervous system and bodily movements. Whilst these debates remain unresolved it seems clear that skill acquisition, retention and transfer can all be directly affected by our conscious focus.

2.5 Underpinning evidence

As much of the research into attentional focus has discovered a clear and significant cause and effect relationship between conscious focus and measurable output, scientists have, understandably, been interested in eliciting the psychological processes concerned. They have also sought to evaluate any neurological, physiological and biomechanical effects of varying focuses and to ascertain any underlying consequences and benefits involved.

2.5.1 Psychological issues

Psychologists have, for some time, been aware of the limitations of human working memory; it is considered to be a potentially constraining factor which may explain an internal focus deficit in relation to an external focus (e.g. Poolton *et al*., 2006). Working memory is the function which provides us with our conscious thoughts – it is our 'on-screen display' on which we can 'view' sensory information as well as import knowledge from our long-term memory stores to be considered. The capacity of working memory is generally regarded as being seven discrete pieces of information plus or minus two (Smith *et al*., 2003, p.276). The length of time for which unrehearsed input can be retained (as originally measured by the Brown – Peterson task) is approximately twenty seconds (Brown, 1958; Peterson and Peterson, 1959) Critically, it would appear that this function is not trainable or extensible; if the memory is full then any new input will displace existing information (Smith *et al.*, 2003, p.276).

Domkin *et al.*, (2013) highlight that having a larger working memory capacity attenuates the impact of distractors by permitting an earlier resumption of the primary task; though once the most simple of physical skills are considered it soon becomes apparent that such a small capacity may rapidly be overwhelmed by the volume of sensory input which might need to be simultaneously processed. Clearly, anyone trying to consciously control their movements will do so using significant working memory resources which, whilst inherently slow, may be additionally detrimental if such control acts to interfere with or constrain the body's subconscious mechanisms. An internal focus therefore seems likely to place greater strain on working memory function as it requires the performer to consider bodily movements (in a motor skill) which seem less likely to be thought about if the focus is on outcomes and the environment. As skills become increasingly open the amount of environmental information to be processed will grow, eventually leading to the participant being unable to function effectively – or at all. Researchers who see working memory as a central element of motor skill performance anticipate and point to evidence which indicates an internal focus deficit as opposed to an external focus advantage (e.g. Masters, 1992).

A further issue associated with working memory is the potential conflict between coaching input and performers' required output. Psychologists have highlighted that working memory provides transient storage and the ongoing processing of sensory stimuli. Evidence suggests (Baddeley, 1992) that, coupled to a 'central executive' function, working memory has two 'slave' sub-systems: a 'visuo-spatial sketchpad' which manages images, shape and focus, and a 'phonological loop' which provides short term acoustic rehearsal. Considering that in most coaching and learning situations performers receive significant volumes of information verbally from a coach, and the majority of physical skills require a significant use of vision and kinaesthesia, then a further conflict may also be created – particularly if instructions or feedback are provided concurrently with activity and linked to an internal attentional focus.

In addition to a potential cognitive overload caused by a volume and/or type of information which exceeds memory capacity, coaches and participants have long been concerned about the detrimental effects on performance of anxiety. In 1974 Mortlock subdivided Yerkes' and Dodson's 1908 arousal versus performance graph into four separate sections. The point from which an individual's ability to tolerate anxiety or arousal during performance suddenly diminishes, with a commensurate rapid decline in skill, he labelled 'Misadventure'. Mortlock suggested that what constitutes a very productive and beneficial learning and performing environment for one person may constitute a 'misadventure' for others, though he does believe that such tolerance can be developed with improved technique and confidence, i.e. our ability to function under pressure and to adapt to stress is different for everyone. It may be the case that encouraging or adopting an internal focus of attention will distract a performer from critical environmental cues, slow their response, place unnecessary load on memory systems and increase their anxiety. This is turn may lead them to reach a point at which they can no longer cope earlier than might otherwise have been the case. Masters (1992) and Masters *et al*. (1993) contend that individuals differ in their propensity to consider explicit, declarative information while performing. This tendency to 'reinvest' such knowledge seems to undermine performance in such individuals more than those who either don't reinvest or don't have the explicit information to use in such a manner (e.g. Jackson *et al*., 2006; Weiss, 2011; Masters, 2000).

Baumeister (1984) researched the impact of anxiety on performance and, in particular, the propensity for even expert performers to 'choke' under pressure. His research consisted of six experiments which found, paradoxically, that apparent incentives often led to decrements in function. In particular, he studied the impact of implicit competition, the presence of an audience and a cash prize; in all cases he found that the increased importance of good or improved output actually induced a level of performance anxiety which undermined the participants' ability. More relevant to the present work perhaps, is that in three of these experiments Baumeister specifically examined the impact of self-consciousness during performance. The findings showed that individuals who, under conditions of increased anxiety became more conscious of their own movements, also performed less well. As a result of this he proposed that 'choking' affects skills and co-ordination when the pressure to perform increases conscious attention on one's own process, this in turn leads to an attempt to control and override automatic and 'overlearned' processes with a resultant disruptive effect. Such effects are not just related to individuals: Baumeister and Steinhilber (1984) found that the home advantage that most people expect teams to benefit from can actually work in reverse. In situations of increased anxiety or game importance, such as one-off cup games or end of season deciders, playing at home increases expectations and stress and often has an adverse impact on the team's performance. These studies and several since (e.g. Masters, 1992; Beilock and Carr, 2001; Wang *et al.*, 2004) draw parallel conclusions to those being presented by researchers into attentional focus.

In support of Baumeister's model, several studies have shown a link between high levels of anxiety and an internal focus. Wells and Papageorgiou (1998), Woody (1996), Liu *et al.* (2005) and Jackson *et al.* (2006) report that anxiety increases with a self-focus and *vice versa* - it appears to increasingly redirect performers' attention from goal directed behaviour internally to their own anxiety. Fox (1993) points out that this issue may be exacerbated for individuals with high trait anxiety as they find it more difficult to maintain attentional focus in the first place. Bell and Hardy (2009) evaluated the impact of anxiety and attentional focus on the performance of skilled golfers. In one of the first studies to differentiate between types of external focus they found that a distal focus (as opposed to a proximal focus) led to superior performance compared to all other conditions and irrespective of anxiety. In the context of the current thesis this is an important finding in that it demonstrates an external focus can be optimised or at least improved. Whilst there are factors which golfers have to adapt to during play, such as weather and terrain, it is still a relatively closed skill in which the participant dictates the time and pace of play. Identifying the most advantageous focus in more open skills may be of great benefit to performers and coaches alike. To my knowledge this avenue of study has yet to be explored.

Bardel *et al.* (2012) also studied the interaction between emotional stress and focus. They report findings which indicate that an internal focus deficit may occur as a result of concentrating not just on bodily control but also on other types of factors such as emotions. Whilst not strictly an attentional focus study (because the internal focus was not on movement mechanics), they found that participants who concentrated on their emotions (internal focus) tended to turn their attention away from perceived dangers in the activity environment and therefore dealt with them less well. This is akin to the physical reaction observed in activities when the performer shies away from a challenging or intimidating situation. The results showed that the individuals who consciously attended to the perceived threat (external) as opposed to their emotions, were able to take more timely, effective and appropriate action. If an internal focus on emotions coincides with a conscious focus on physical movements and a reduction in attendance to important issues in the activity environment, it seems possible that effective skill could be undermined.

It is worth emphasising that not all anxiety is necessarily detrimental to performance, indeed the models proposed by the aforementioned Yerkes and Dodson and Mortlock argue that a moderate level of arousal is actually stimulating and motivating and can lead to more effective output. This notion has been supported by work produced by Eysenck and Calvo (1992) and Eysenck *et al.* (2007): they found that neural processing effectiveness and attentional focus on task relevant information was enhanced with a certain level of anxiety, though that this could have an inhibitory impact as it increased. Physiological studies (see Lupien *et al.*, 2007) have demonstrated that the most favourable levels of glucocorticoids circulating in the bloodstream occur with moderate arousal. These operate, for example, to mobilise energy and deliver it to the body's muscles (epinephrine) and to mediate the body's stress response so that homeostasis is maintained and function not impaired (cortisol). An individual that is either under or over stimulated appears more likely to be detrimentally affected (in a performance sense) and to have sub-optimal glucocorticoid levels. Lupien *et al*. (2007) explain that this increase and decrease in function follows an inverted U-shaped curve.

It would appear the research into attentional focus, and Eysenck *et al.*'s (2007) work on attentional control, point to a conclusion that performers might be best advised to concentrate on externally focused, task relevant criteria if they are to maximise their performance and minimise the potentially negative impacts of anxiety. Future studies into the impact of an internal focus on movement mechanics and its effect on anxiety as well as physical performance factors may prove valuable to performers and coaches alike.

2.5.2 Physiological evidence

As well as psychological correlates with evidence for an external focus benefit, in recent years in particular, significant research efforts have been made to understand the physiological implications of different attentional focuses.

In 2002 McNevin and Wulf reported the impact of attentional focus on Fast Fourier Transform[5] (high frequency positional adjustments) whilst participants tackled a supra-postural task (lightly touching a hanging sheet whilst instructed to stand still). Under the internal focus condition with a focus on the hand, the volunteers had significantly lower frequency Fast Fourier Transform than under the external focus condition (focus on the sheet). This indicates that, in this context, the body's natural ability to position itself accurately is enhanced when automated systems are relied upon rather than using conscious control mechanisms.

Radlo *et al.* (2002), in a study of novice darts players, also measured physiological responses under different attentional conditions. They discovered that those adopting the expert (external) focus demonstrated a drop in heart rate immediately before release whereas the internally focused players had a

[5] Fourier Transform is named after the 19th century French mathematician and physicist Joseph Fourier. Its application in motor learning is related to the fact that improved fine motor control is associated with higher frequencies and smaller movement corrections to the point whereby such tuning becomes imperceptible.

heart rate increase. In a later study of darts players Lohse *et al.* (2010) measured the electrical activity in the *triceps brachii* using electromyography[6] (EMG) as well as the biomechanics at the shoulder joint of the throwing arm under different attentional focuses. The results show that an external focus (on the flight of the dart) significantly reduced the EMG activity in the relevant muscles as well as demonstrating increased shoulder movement variation (increased degrees of freedom and less rigidity). This enhanced economy was also coupled to less preparation time and increased throwing accuracy under the external condition. From an economy point of view an external focus could confer a significant benefit to performance if these results prove common to all sporting situations.

Several other studies have been conducted using EMG measurements: Vance *et al.* (2004) evaluated the effect of an external versus an internal focus on the performance of biceps curls. They found that an external focus (on the curl bar) produced faster movements and lower integrated EMG[7] activity than when the focus was on the arms (internal). To control for the possible impact of speed of movement a second experiment was conducted in which the participants had to curl the bar in time with a metronome. Once again, a significant reduction in

[6] Electromyography (EMG) is a method of calculating the electrical activity in skeletal muscles. In motor learning research it can be used to measure activation levels, muscle cell recruitment order and biomechanical efficiency. Whilst it is usually measured using intramuscular probes in medical applications, it is more commonly assessed using surface electrodes in sports science studies.

[7] Integrated electromyography (iEMG) measurements are ones which have not been processed by bandpass filtering. See Merletti (1999) for a comprehensive explanation of the set standards for EMG measurement.

electrical activity was measured under the external focus condition. In a further experiment Zachry *et al.* (2005) studied EMG activity in the biceps and triceps of basketball players whilst performing free throws. The results once more demonstrated increased muscular economy under an external focus condition as well as enhanced accuracy. That an individual's conscious focus is manifested at the neuro-muscular level is an important finding which not only relates to economy but also to speed, accuracy and efficiency.

In 2009 Marchant *et al.* used EMG measures to investigate whether attentional focus was implicated in force production. Using single arm elbow flexions under control, internal and external conditions they report that an external focus resulted in significantly higher peak, net joint torque[8] and a greater integral[9] of the torque versus time curve than under the other two states. They also found lower peak EMG and lower mean, integrated EMG under this condition, this indicates that force production was greater with less muscular activity in an isokinetic exercise (movement at a constant speed) using an external focus. A recent follow-up study by Greig and Marchant (2014) using the same activity and conditions though with elbow flexions at three different speeds, also found an external focus to be associated with significantly lower EMG measures in all circumstances. However, the different flexion velocity trials found an external focus benefit only in the slowest of the three tests,

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[8] Torque is a twist to an object created when an applied force causes it to rotate around an axis, fulcrum or pivot.

[9] The integral is the area under a graph line. In this case a greater integral indicates that torque is effective over a greater range of movement and/or is more effective over a period of time.

indicating that movement speed may be implicated in attentional effects. Considering the growing emphasis on strength and conditioning training across a wide variety of sports, studies such as these provide potentially crucial information for both coaches and performers to be aware of. Not only could it result in greater force production, it could also reduce the attendant injury risk in such training due to the reduction in muscular effort required to overcome a set resistance.

Marchant and his colleagues were not slow to realise the implications of their earlier work, their 2011 study of experienced weight training athletes further demonstrated a significant benefit to performance as a result of using an external focus. In three trials using different weight training exercises they found that an external focus of attention resulted in significantly more repetitions to exhaustion than did an internal focus. Not only did this endurance benefit relate to an external focus advantage, in one trial it also resulted in an internal focus disadvantage in relation to the no-focus control condition. Furthermore, the mean difference in repetitions was easily apparent as they were so sizeable: in the first trial using an assisted bench press the external focus output was 30.7 compared to 27.57 in the internal focus trial; in the second experiment the relationship was 10.82 to 9.58 in a free bench press and in the final test using free squats it was 11.06 to 10.06. When it is borne in mind that the control condition also lagged significantly behind an external focus the potential benefits to performance become apparent.

In 2010 Wulf *et al.* used EMG measurements alongside an assessment of vertical jump height under both external and internal focus conditions. As with the studies so far discussed, the external focus trial produced greater jump height with reduced muscular activity. More effective and efficient movement occurred with a focus on the calibrated board rather than on the hand touching it. This augmented studies previously conducted by Wulf *et al.* (2007) and Wulf and Dufek (2009) in which they had also measured jump height against attentional focus. In the 2007 work the participants' centre of mass displacement was measured as well as the maximum height reached which demonstrated that the external focus advantage was to force production rather than an alteration to joint mechanics; in the latter study a force measuring platform was used to actually measure the differences. The 2010 study also found an enhanced, mean jump height under an external focus indicating that greater force was being produced – this was supported by the fact that centre of mass displacements were also greater.

As well as force, Wulf *et al.* (2010a) also investigated the jump impulse and the joint biomechanics to see if there were any attention related differences. Impulse relates to the amount of time taken from the point at which 50% of the body weight is pressing on the force platform to the point when it reaches zero. The researchers found that jump impulse was significantly shorter when the participants were externally focused on the point they were jumping to. Furthermore, their biomechanical analysis indicated significantly greater lower extremity joint movements with an external focus which they interpreted as a beneficial improvement in degrees of movement freedom. This they believe permits greater automatic selection of the most appropriate movement as well as increased speed of adaptation.

Lohse *et al.* (2011) investigated the neuro-muscular impact of attentional focus on an isometric[10], seated, force production task. They discovered, via EMG, that an external focus on the force plate (as opposed to an internal one on the legs) demonstrated reduced antagonist muscle co-contraction though had no impact on the force produced by the agonist muscles. They also report that the external focus produced higher force values. In human limb movement the leverage and force produced is modulated and controlled by opposing muscle groups; the agonist applying the force against the resistance being balanced by the antagonist. For example, in the case of this study the main agonists would be the *quadriceps femoris* (thigh) whilst the hamstrings (*biceps femoris*) would act antagonistically. It seems likely that we naturally exert an appropriate amount of antagonist co-contraction which functions to protect muscles working against the external resistance rather than to impede them unnecessarily. In Lohse *et al.*'s study the internal focus condition almost tripled the activity of the antagonist muscle. This extends the previous EMG studies and again demonstrates the detrimental impact on muscular economy caused by an internal focus on bodily movement.

[10] Isometric exercises are ones in which the joint angle and muscle length do not change during contraction. They can be either 'overcoming', in which force is applied against a fixed object, or 'yielding', whereby a fixed position must be maintained whilst opposed by resistance.

In 2012 Lohse and Sherwood followed up the previous research with two further EMG based experiments. The first of these identified that an internal focus on the foot (specifically the part relating to the agonist muscle) reduced force accuracy and increased antagonist muscle co-contraction; they further report that force accuracy and the magnitude of co-contractions correlated positively. This study was conducted using a plantar flexion task against a fixed force plate – which formed the external focus point. Accuracy was defined in terms of how well the participants could apply 30%, 60% and 100% of their maximum voluntary contraction; it was discovered that the more the participants tried to consciously control force application the less precise they became. In their second study the researchers used the same trial activity though analysed the effect of attentional focus on muscular fatigue as participants attempted to deploy the three levels of contraction. They once more found that an internal focus on the foot caused less efficient intramuscular contraction which, by implication, would lead to earlier fatigue. Furthermore, they noted that the increase in co-contractions was most evident early in the agonist muscle's activity. Both of these studies have clear repercussions for the coaching and performing of activities in which the application of force has to be tightly controlled.

Whilst the majority of EMG economy studies concur in discovering an external focus benefit, this is not an entirely universal finding. Kal *et al.* (2013) measured EMG activity in a seated leg movement task in which participants had to move their foot forward and backward with either an internal or external focus. As well as this single task design the researchers also ran the trials with the addition of a cognitive, secondary task – if participants are able to maintain effective motor function whilst occupied with such a concurrent, dual task this demonstrates a level of motor automaticity. If this subconscious control is disrupted by, for example, an internal focus though not with an external one, this then lends weight to the Constrained Action Hypothesis. The study did indeed report a strong external focus benefit in terms of the primary task, especially in the dual task conditions, though found no significant difference in terms of electrical activity in the muscles. However, it should be borne in mind that whilst EMG readings were similar under the various focal conditions, movement effectiveness was significantly superior under external focus instructions which indicates that for the same muscular activity more efficient performance resulted.

Other avenues of physiological assessment have also been pursued in relation to the effects of conscious cognitive control on performance: Hessler and Amazeen (2009) investigated the impact of focusing on breathing whilst exercising. In particular, they were interested in understanding the impact on motor respiratory control of requiring individuals to fix their inhalations to a point in the exercise cycle when movement was at its maximum velocity. This, they claim, would not be the natural point chosen as performers tend to anchor their inhalations to a point in the exercise cycle when the mechanical load on the lungs is low as this is more efficient e.g. when the foot strikes the ground in running and walking or, perhaps more obviously, during effortful swimming.

They also argue that metabolic effectiveness is optimised when breathing and movement are synchronised (known as phase entrainment); though humans do have the ability to vary the movement-breathing ratio, i.e. it does not need to be one movement cycle to one breathing cycle. Phase entrained inhalations anchored to low lung load positions should therefore place less physical demand on an individual leading to maximum metabolic efficiency and economy. The researchers found that both cognitive and physical constraints could disrupt the natural motor respiratory cycle which may demonstrate that attentional focus internally on this system can be disruptive during physical activity.

Schücker *et al.* (2009) studied physiological impacts of conscious attentional focus on running economy. Three treadmill conditions were used for trained runners in which they had to run at 75% of their personal VO_2 max[11] whilst focusing on their running movement (feet in particular), their breathing or their surroundings. The researchers report that running economy improved significantly with an external focus (surroundings) in terms of the athletes' VO_2 (volume of oxygen used) though there was no significant benefit to blood lactate levels or heart rate. Whilst this study may demonstrate an external focus advantage to respiratory efficiency an examination of the methodology does raise some questions. Firstly, the fact that no control condition was used does

[11] VO_2 max is the maximum volume of oxygen an individual can transport and process during incremental respiratory effort. It may reflect the physical fitness and the physical capacity of an athlete. VO_2 max is usually measured in millilitres of oxygen per kilogram of bodyweight per minute (ml/(kg·min)).

not allow for a comparison with a no-focus benchmark and therefore misses the opportunity to identify focus advantage and disadvantage relative to a more normal measure. More of an issue perhaps, is that the external focus condition employed consisted of the runners watching a video simulating a running route at approximately the pace they were moving. The measured benefit of this condition could therefore be due to the fact that a visual rather than a conscious focus was used or because it more closely replicated real conditions. Increased confidence could be placed in this otherwise interesting result if the protocols had controlled for vision and used a different conscious focal point in the external focus trial.

Researching attentional focus in an endurance activity, as Schücker *et al.* did, is certainly an avenue worth pursuing as it could provide valuable information on the most efficient and economical focus in terms of both physiological measures and performance outcomes. Interestingly, Tenenbaum (2001) and Hutchinson and Tenenbaum (2007), claim that rising exercise intensity is linked with an increasingly internalised attentional focus in that it is only easy to switch and choose focal points when work loads are relatively low. Other researchers (e.g. Morgan *et al.*, 1983) claim that distracting runners from the discomfort of high intensity exercise allows them to increase their exercise duration. What is clear from these and other studies is there is scope for further work to establish the impact of conscious attentional focus on endurance activity – particularly at a variety of workloads.

As mentioned in the theory section earlier (Section 2.4.4), the findings of some physiological studies of biomechanical and EMG measures seem difficult to reconcile with the generalized motor programme notion. For example, different muscle co-contraction ratios between agonists and antagonists as a function of the performer's attentional focus seen in force production tasks (e.g. Lohse and Sherwood, 2012; Vance *et al*., 2004) do not seem to be in line with the notion of invariant relative forces. If those forces were controlled by the same motor programme, a proportional change in the EMG activity of agonist and antagonist muscles would be anticipated rather than different proportions when the attentional focus is changed – such as Lohse *et al*. (2011) found when electrical activity almost tripled with an internal focus. Similarly, how can the more efficient motor unit recruitment under external relative to internal focus conditions be explained (e.g. Lohse and Sherwood, 2012)? Furthermore, findings of functional variability seen under external, but not internal, focus conditions (in the same performers) (Lohse *et al*., 2010; 2014), as well as in skilled performers but not beginners (Müller & Loosch, 1999), seem to be difficult to rationalise from a motor programme perspective. In these circumstances a dynamical systems view may provide a better explanation in that it would encompass such non-linear changes.

Section 2.5 Summary

Notwithstanding occasional methodological issues, the bulk of the scientific evidence cited in this section appears to strongly support the notion that an internal, conscious focus of attention is unhelpful in aiding performance. A wide range of psychological and physiological studies have almost universally found an external focus benefit to movement economy and efficiency which seems likely to naturally translate into improved and maximised athletic output. The evidence shows that motor control in force production is negatively affected by an internal focus, which in turn adds weight to the notion that we suffer a 'system wide' constraint when we try to consciously control our own bodies, especially in circumstances where there are established automatic processes. The majority of these findings concur with the predictions of the Constrained Action Hypothesis and also suggest that a dynamical systems approach may be valuable in explaining non-linear shifts in performance.

2.6. Laboratory Based Research

When the possibility of a benefit to performance and learning as a result of using an external, conscious focus of attention became apparent, much of the early research was conducted in a laboratory setting. This environment is important as it permits stringent control of variables which might otherwise confound the results. It also allows accurate manipulation of independent variables and rigorous measurement using highly calibrated instrumentation; this confers a high level of reliability and verifiability. Laboratory research can provide the theoretical foundations on which applied studies can then be built.

Following her 1996 'Eureka!' moment whilst attempting to improve her gybing on a windsurfer, Gabriele Wulf decided to investigate whether this ostensible effect could be replicated experimentally. With this in mind she first questioned and examined the impact of instructions on performance. Two studies (Wulf and Weigelt, 1997) used a ski-simulator to replicate a slalom skiing-like motion; the task being to time movement frequency to match that of a metronome whilst at the same time maximising movement amplitude. The participants undertook three trials having been randomly placed into either an instructed or uninstructed group (the instructed group being asked to exert maximum force on the 'skis' immediately after they had passed the centreline of the machine). In the first experiment there were no significant differences between the groups until the final trial in which participants were informed they would be evaluated by an expert via a one-way screen. This significantly increased the performance gap between the conditions and saw the uninstructed group fare much better – indeed, having instructions appeared to actually degrade those participants' performance, particularly under pressure.

In the second experiment Wulf and Weigelt (1997) examined whether providing instructions later in the development process might be more effective, reasoning that once a level of task competence had been achieved the participants may find it easier to assimilate additional information designed to assist them. The results demonstrated that, whilst those taking part gradually improved over the practise trials, when the additional information regarding when to apply pressure to the skis was introduced, the standard of performance dropped markedly. The researchers interpreted this as evidence of an instruction disadvantage and postulated that there may be many coaching and learning situations in which well-meaning trainers may actually be undermining their students' development.

In 1998 Wulf, Hoß and Prinz conducted two studies to assess retention (learning) under a variety of instructions. The first experiment used the ski simulator again, though on this occasion differentiated between the instructions provided so that one group were tasked to focus on their feet during the movement whilst a second was required to think about the mechanism (wheels) under their feet. These internal and external focus groups were joined by a control group who received no attentional focus instructions; this would enable the researchers to identify whether the different focus conditions had any effect and, if so, whether they were advantageous or not. The results showed a significant benefit to learning of using an external focus of attention compared to both an internal focus and no-focus approach. There was no significant difference between the latter two trials.

The second experiment in this study sought to ensure that this outcome was not just a function of the ski simulator task, therefore the same protocols were run again though this time using a highly calibrated seesaw called a stabilometer[12]. Participants had to stand astride the pivot point and either balance it as well as

[12] I was fortunate enough to be invited to the University of Nevada in 2011 by Professor Wulf when she learned of my research. She kindly showed me around her laboratory and encouraged me to try, at first hand, some of the experiments she had used – including the stabilometer task.

possible whilst thinking about their feet (internal focus), or as they considered black marks on the device immediately in front of their toes (external focus). As before, the external focus group performed significantly better than their counterparts tellingly, with a very small and subtle alteration to the instructions. In both the tasks used above, vision was inherently controlled by virtue of the fact that the conscious focal points were very difficult or impossible to observe and the natural tendency of participants was to gaze directly forwards.

Shea and Wulf (1999) extended the research by examining whether the focus benefits discovered with prior instructions would also be present with feedback to participants on their performance. Four groups of participants were randomly assigned to either the same internal and external focus trials as previously used on the stabilometer, or to one of two groups receiving concurrent feedback on their balance via a computer monitor in front of them. The volunteers were informed that the feedback related to either their feet (internal) or the platform (external). Once more the performance of the external focus instruction group was significantly superior to that of the internal focus group though the participants receiving the external focus feedback also achieved a higher degree of stability than their counterparts. Interestingly, not only was performance enhanced in both cases, a later retention test also showed an external focus benefit for both instructions and feedback. The researchers had not anticipated this as previous research into the effects of concurrent feedback had shown that participants became dependent on it and, once removed, suffered a significant decline in retention and transfer (e.g. Van der Linden *et al.*, 1993; Winstein *et al.*, 1996). Notwithstanding the results of this study, it does seem possible that providing feedback visually may, in itself, be a confounding factor (i.e. between visual and conscious attention) and, assuming this is not the case, that the position of the screen enhanced the instructed focus of the participants (by distraction) irrespective of the feedback. A later study by Danna-Dos-Santos *et al.* (2008) did indicate that participants were unable to control their body sway using visual feedback alone which, as they used an almost identical feedback setup, perhaps ameliorates the concerns above. Remaud *et al.* (2012) further report that vision seems only to aid in compensating for an increase in attentional demand during more challenging postural tasks.

In 2001 Wulf *et al.* tested the assumptions of the Constrained Action Hypothesis by assessing participant reaction times whilst they dynamically balanced on the stabilometer. As before, the external focus trial produced smaller balance errors and higher frequency corrections than the internal focus condition – indicating more automatic control. This was reinforced when a concurrent reaction time task demonstrated faster responses from the externally focused volunteers suggesting they were dealing with a lower attentional load. McNevin and Wulf (2002) further tested static balance by using a supra-postural task (touching a hanging sheet) in addition to having to stand still on a flat, immovable surface with their eyes closed. Whilst the secondary task did increase postural sway under both focus conditions in relation to a no-touch control condition, the frequency of responding (Fast Fourier Transform) was faster under the external condition thereby indicating improved static balance.

In an extension of the supra-postural task study, Wulf *et al*. (2004) used a within-subjects design in which volunteers had to balance on an inflated rubber disc whilst holding a pole horizontally. There were four focus conditions used: an internal and external focus on the postural task (feet and disc) as well as an internal and external trial on the supra-postural task (hands and pole). The outcome showed that both external focus conditions were superior to their internal focus counterparts in measured stability though, in a result which seems to imply that postural task goals are subservient to supra-postural goals, focusing on the pole (supra-postural) had the same impact on the postural task as did focusing on the disc. Whilst the direction of focus on the postural task (disc or feet) had a significant effect on postural sway, it made little or no difference to the control of the pole. This, apparently, renders the need for a postural focus redundant if there is an external focus on a secondary manual task. The researchers believe that this reinforces the notion of a 'smart' motor system that optimises control based on the outcome or effect desired, though there is a difference in effect between the two studies above: In the McNevin and Wulf (2002) study, postural sway became less controlled under both focus conditions in comparison with the control condition whereas in the latter study postural control was improved with a supra-postural task. Huxhold *et al*. (2006) found that supra-postural tasks were beneficial to postural sway until such tasks became so challenging that they created competition for available cognitive resources. At this point they found that the additional task began to have a detrimental effect; this occurred earlier with older participants. It would seem therefore, that the type and difficulty of the tasks being performed also makes a difference as well as, possibly, the availability of visual feedback to the participants.

Vuillerme and Nafati (2007) examined the impact of an internal attentional focus on 'quiet standing' in relation to a no-focus condition. Interestingly, they found no significant difference in postural sway as a result of the conditions, though measurements which indicate 'stiffness' of the ankle joint, and therefore the amount of neuro-muscular effort being deployed, indicated a reduction in efficiency with an internal focus. It is unusual (in attentional focus research) for there to be a performance disadvantage as a result of an internal focus relative to a no-focus control – more commonly there is no significant difference – though the authors' belief is that the effect would have been exacerbated and, indeed, have impacted on postural sway, had they increased the difficulty of the task. As Roerdink *et al.* (2010) highlight, even a relatively small difference between tasks can affect the investment of attentional resources. Stins *et al.* (2011) examined the neuro-muscular impact of cognitive and affective (physical) dual tasks as well as that of anxiety (induced by height). They were unable to find evidence to support the notion of 'ankle stiffening' except under the anxiety condition. This seems to indicate that, despite attentional effects, the mechanism and impact of attentional focus on the body is not yet clearly identified and requires further research.

In a test of the task difficulty issue Wulf *et al*. (2007) constructed a series of balance experiments ranging from standing still on a solid surface, to standing on a foam block to standing on an inflated rubber disc with either two feet or one foot. In all cases an interaction between stability and attentional focus (internal, external, control) was measured. In the comparison between the solid and foam surface there were no focus effects detectable on the solid surface and only an external condition benefit in relation to the control trial on the foam – though postural sway was reduced in both tests under an external focus. With the more difficult balance task on the disc however, there was a significant external focus benefit whilst the internal focus was close to being significantly less effective than the no-focus condition (p = .059). Unsurprisingly, standing on one leg was even more challenging than having both available though an external focus was beneficial in aiding stability. This does beg the question as to why task difficulty, as a function of an individual's capabilities, demonstrates an enhanced attentional focus effect. It may well be that at low levels of challenge automated systems control motion irrespective of focus and there appears little need to intercede. As difficulty increases, individuals may feel induced to intervene to try and improve control; if they do this using an internal focus it would seem to have no or a negative effect whereas an external focus is found to be significantly superior in such situations as it has little impact on automated processes and may actually enhance performance. This then would seem to further support the basis of the Constrained Action Hypothesis.

An issue of particular interest to this thesis was tackled by McNevin *et al.* (2003) when they examined the impact of the distance from performers of an external, conscious focal point. Using the stabilometer, the researchers assessed the impact of an internal focus (on the feet) against three different external focal points on the platform (immediately in front of the toes, between the toe markers adjacent to the midline and 26 centimetres to the outside of the toe markers). These they named 'near', 'far inside' and 'far outside' respectively. Four matched groups of participants spent two sessions over two days practising under the various conditions; on the third day a retention test was conducted without instructions. The results showed that, whilst the internal focus group was consistently the poorest during the practise trials, and the most distant external points the most effective, there was no significant effect of focus. The day three retention tests did though demonstrate a significant effect of focus and distance of focus; the two 'far' focus points produced similarly lower error scores (root mean square error) as well as increased speed of correction (Fast Fourier Transform). These two conditions were significantly superior to the 'near' and the internal trials in these regards – the 'near' focus was just outside the significance value to demonstrate a benefit over the internal test (p = .06).

It does seem unusual that there was no attentional focus effect on initial performance in McNevin *et al.*'s study when this has been commonly found using this apparatus; it is also odd that the, previously effective, external focus ('near') had an insignificant impact in this study, though the authors do not comment on these apparent reversals. These results do though, have potentially important connotations as understanding that an external focus aids learning does not, in itself, assist in where that focus should be most effectively placed or even if it should be fixed. McNevin *et al.* (2003) show that the distance of focus is important to the degree that significant differences appear between points which are all relatively close to each other and the performer. As many sports and activities, particularly open skills, require the participant to move effectively whilst processing multiple environmental cues, understanding how to optimise the external focus appears to be a very worthwhile avenue for further research.

An additional question to be answered by researchers concerned the impact of attentional focus on transferability of learning to a novel task or situation. Totsika and Wulf (2003) examined this using a pair of 'pedalos' which attach to the feet: wheels are operated by the feet driving the standing plate around a crank. As has become common, there was a significant benefit to initial performance with an external focus though, of more interest, three separate and increasingly challenging transfer tests also demonstrated a significant external focus performance improvement. The transfer tests consisted of moving at speed, moving backwards and moving whilst performing a dual task (counting backward in threes). In all cases performances were reduced in the transfer conditions though an external focus mitigated the effects of the novel situation and also demonstrated a more rapid transition to the altered circumstances than did the internal focus. This is a potentially important finding as in most applied skills there is a level of adaptation required which could well be enhanced and speeded with instructions, feedback and practise which utilises an external focus of attention. Conducting studies in applied contexts in which transferability is important may help clarify this issue.

Jackson and Holmes (2011) questioned the claimed benefits of attentional focus manipulations, arguing that an external focus should only be beneficial when the point of the task is also external – they hypothesised that an internal focus should, likewise, be beneficial when the assumed objective is also internal. With this in mind they constructed a balance study which deceived the participants into believing that such internal and external objectives existed whilst measuring their performance against an internal and external focus. Using a stabilometer-type balance task with an internal focus on the feet and an external focus on the board, they further subdivided each group into one which was led to believe that the point was to keep their feet level and the other in which the point was to keep the board level. Their results showed that the external focus (on the board) was significantly beneficial when paired with an externally oriented task objective (keeping the board level), though no benefit was discovered in task and focus combinations which included either the internal focus or the internal objective. Whilst Jackson and Holmes' hypothesis was not supported in this study, they reiterate their concern that the majority of attentional focus studies may have automatically favoured or provided an external point to the activity used, and this may have affected the results. This may or may not be the case though, in this study, it is unclear how the participants could easily differentiate attention between the intended conscious focus and the point of the task as explained. Of the four condition combinations only one was exclusively external and this one demonstrated the same significant benefit to performance as is commonly found in other studies.

In a further extension of the laboratory based research, Nafati and Vuillerme (2011) examined the impact of a dual task on performance. In a control condition participants were asked to stand on a force platform as immobile as possible whilst an experimental condition required them to do the same whilst performing a concurrent, digit recall task. In addition, the researchers also controlled for working memory capacity via a pre-test to ensure the level of difficulty was equalised for all volunteers. The results showed that static balance was significantly superior when the dual task was applied. The fact it was completely irrelevant to the balancing objective had no detrimental effect and seems to demonstrate that in situations when a performer may be attempting to consciously control their movement a distractor may permit subliminal control processes to perform that task more effectively. It may well be that if such a distracting task acts to prevent a performer considering their bodily control (a potentially destabilising focus) or any negative emotions which they may be experiencing, then it may indeed be a positive tool. If on the other hand such distraction interferes with critical functions or technique then the opposite may be the case. It would seem that research to establish the limitations of different types of dual tasks may provide insight which may be especially informative to those working in an applied coaching environment.

Following the earlier reported EMG experiments by Lohse *et al.* (2011) and Lohse and Sherwood (2012); a further investigation using the seated, plantar flexion force production task was conducted (Lohse, 2012), though in this case the emphasis was on an assessment of attentional focus effects on training, retention and transfer with a distinction being made between pre-movement time and motor control. Lohse anticipated that pre-movement time would be extended with an internal focus of attention as it would be creating explicit control of both task goals and movement parameters – the first a function that seems naturally to be conducted implicitly (subconsciously). He hypothesised that an external focus would improve pre-movement time as only the task goals would be explicitly controlled, therefore reducing processing requirements. In the event an external focus did provide a pre-movement time advantage in early trials though this effect diminished as the trials continued – perhaps as the internal focus information became automated. The retention and transfer tests did, however, show a significant external focus benefit to force production accuracy; this was particularly apparent when participants attempted to apply 25% of their maximum voluntary contraction.

Lohse (2012) is an informative study on several counts: firstly, it demonstrates that an external focus may assist with the automaticity of motor control in the early stages of learning as evidenced by the initial impact on pre-movement times. Secondly, it provides more rigorous evidence of an external focus benefit to transferability in support of Totsika and Wulf's (2003) study. Finally, it demonstrates that accuracy of force production may be most beneficially affected by an external conscious focus at sub-maximal loads – which may have significant implications for many activities where such precision is required.

Carpenter *et al.* (2013) used a computerised, speed aiming task to assess performance, learning and transfer with an internal (the hand that moved the mouse) versus an external (on-screen cursor) focus. Their results show that an external focus benefit was not immediately apparent in the first trial (performance) though developed early in the second practise session to a point where it again became non-significant. The reason for this is unclear though it may have been as a result of the testing regime (e.g. a ceiling effect which equalised the performances) or it might be that with repeated practise the internal focus handicap is overcome. This result does also contrast slightly with Lohse's (2012) study in which external focus benefits were seen early in practise before dissipating, though in both studies an external focus led to acquisition of fast responses sooner relative to an internal condition. In the retention and transfer measures an external focus benefit persisted, thus reinforcing the notion that an external focus is advantageous to learning and adaptation. Carpenter *et al.* (2013) also point out that this task required participants to manipulate one piece of apparatus as a tool to create an outcome which is wholly different. They argue that this may inform the development of skill in the use of tools, equipment and machinery which commonly exhibit dissonance between movement and its effect.

Section 2.6 Summary

This overview of the attentional focus research questions tackled in the laboratory during the last fifteen years indicates that significant progress has been made. The basic notions that an external focus is beneficial to initial performance, to learning (retention) and to adaptability (transfer) have now been established and appear to be robust phenomena. These effects have been generally durable in relation to an array of tasks and task difficulty as well as with dual and supra-postural tasks (both cognitive and affective) and varied external focus points. Whilst the effects of conscious attentional focus seem widely accepted, the mechanism and theory behind them is the subject of ongoing debate amongst researchers. What is more obvious perhaps is that the critical test of these laboratory findings is whether or not they are replicated in real-life situations and applied contexts. Without demonstrating this it will be difficult indeed to encourage the inclusion of attentional focus research output in learning and teaching strategies.

2.7 Applied studies

Laboratory settings provide a rigorously controllable environment in which critical information on cause and effect can be studied. They also permit in-depth examination of underlying factors; research can usually be constructed and run more swiftly than work in an applied context. There are, of course, limitations, as it is also often the case that in order to perform experiments in a laboratory the activities may have to be contrived or normal actions and skills manipulated to a degree whereby they may no longer closely represent the original form or application. These issues may make it more difficult for scientists to demonstrate the potential implications and benefits and for field practitioners to appreciate and 'import' findings into their work. It is therefore, important to conduct naturalistic studies in applied contexts; matching research conditions as closely as possible to real-life skill contexts. With this in mind a significant amount of work has now been conducted using a variety of sporting and physical skills. A cross-section of these is organised by activity, population and other factors and detailed below.

2.7.1 Golf

Golf has provided a particularly rich 'vein' for examining attentional focus effects due to its controllability even in normal shot taking situations. Wulf *et al.* (1999) conducted the first such study, this involved twenty novice players practising 80 pitch shots at a target using either an internal focus (on the arm swing) or an external focus (on the club swing). The researchers found that both performance and retention were superior under the external focus condition (as measured over 30 trials the following day with no focus instructions). They consider that these results demonstrate the transferability of the effects they had previously found in the laboratory (Wulf *et al.* 1998) to real-life sports skills. Furthermore, they noted a much earlier external focus effect in this study than on the ski simulator and stabilometer, and suggest that this may be due to the much larger distance between the focal points as well as the increase in distinctiveness between the two.

Perkins-Ceccato *et al.* (2003) used a chip shot to examine attentional effects and found that experts benefitted from an external focus as had been found before. In their experiment with novices, however, the results indicated that an internal focus was more effective, leading the researchers to argue that whilst highly proceduralised skills may be disrupted by consciously concentrating on bodily movements, in the case of novices, such a focus may be beneficial and fit in with the stages of learning model of Fitts and Posner (1967). These findings also provide potential support for the Explicit Monitoring Hypothesis (Beilock and Carr, 2001) which argues that an internal focus on declarative task knowledge is beneficial for novices. This unusual result is discussed in greater depth in the 'Expertise' section (2.8.1).

Poolton *et al.* (2006) conducted two experiments using golf putting: following 300 practise trials in their initial study under either an internal focus on the arms or an external focus on the club (the exact instructions are not explained), the researchers found no significant difference between the novice participants in either skill acquisition or retention. When they subsequently ran a transfer test with a secondary task included (counting high and low frequency tones whilst putting) they found that the externally focused groups' performance was unaffected whilst the internal focus volunteers became significantly poorer. Poolton *et al.* attributed this unusual outcome to an increased accumulation of implicit, task related knowledge in the internal condition which then overwhelmed working memory capacity. The internal focus detriment observed (as opposed to an external focus advantage) is, they believe, in line with the predictions of COBALT (Willingham, 1998) and Beilock and Carr's (2001) Explicit Monitoring Hypothesis.

In their second experiment Poolton and his colleagues provided six explicit, technical statements to both putting groups either on their arm and head movement (internal) or on the movement of the club (external). Again, no difference was found between the groups though, when the secondary task was included, both groups suffered deterioration in performance. The researchers argue that external focus instructions may operate to reduce the load on working memory rather than promote automaticity as is claimed by the Constrained Action Hypothesis, though they did not utilise a control group in either experiment which may have clarified the relative effects. Wulf (2013) argues that in the very few studies, such as Poolton *et al.*'s, which have produced a null outcome in terms of attention effects, the sheer volume of instructions which the participants had to contend with may have acted to obfuscate any differences. Whilst this does highlight the different theoretical standpoints, it is certainly the case that this type of result is uncommon.

Wulf and Su (2007) replicated Wulf *et al.*'s (1999) work with the addition of a control group. The results demonstrated that, as before, the externally focused golfers were able to chip the ball more accurately in both performance and retention. Furthermore, the internal focus group had similar scores to those of the control (no-focus) participants demonstrating the more usually observed result of an external focus advantage rather than an internal focus detriment.

Other golf studies have found similar outcomes: Bell and Hardy (2009) found that an external focus was beneficial to expert players whilst pitching, even when they manipulated anxiety levels in all conditions. The internal focus condition produced the poorest scores. This study is discussed in more detail in Section 2.9.1 (Conscious focus distance). An *et al.* (2013) assessed attentional influence on novice golfers: they found that in trying to encourage a weight shift to the front foot immediately before striking the ball (known as 'X factor stretch'), that an external focus on pressing the ground with the front foot was significantly more effective than an internal focus on the foot doing the pressing. Relative to both the internal focus and the no-focus control conditions, the external condition produced more effective learning, i.e. a greater shot distance, improved X-factor stretch and higher maximum angular velocities of the pelvis, shoulder and wrist. This study also demonstrates that a single attentional cue can elicit a measureable learning effect in a complex action when practised by novices; it adds weight to the notion that 'less is more' where instructional load is concerned and challenges the studies which argue that an external focus is unhelpful for beginners.

Shafizadeh *et al*. (2011) conducted a novel study in which they compared an external focus on markers indicating the preferred length of backswing in a putting task, with an external focus on a putting target which was hidden from view and only perceivable due to guides on the ground indicating its position. These two conditions were also compared, in a between groups design, to one in which the participants were provided with both external focuses. The results indicate that the participants provided with the two external points performed more accurately than either condition alone. This led the researchers to argue that when performing a skill the perception and the action involved should not be divorced and claimed their findings to be supportive of Prinz's (1997) Common Coding Theory. They conclude that whilst externally focused information appears to be effective it should be divided between the execution of the movements and the outcome desired.

Using a golf putting task with expert players, Land *et al.* (2013) assessed the link between visual and conscious attention. Using a no-focus (control) condition, a tone counting task (irrelevant) and an external focus on the movement outcome they found that an external focus benefit remained strong even with vision occluded. The researchers believe this indicates that cognitive control underlies the external focus advantage, as opposed to any mediating effect vision may provide, though they comment that the precise mechanism is, as yet, elusive.

2.7.2 Basketball and other invasion games

Basketball or, more specifically, free throw shooting, has provided a relatively stable, closed, discrete skill for the study of attentional effects. Al Abood *et al.* (2002) conducted a study with the primary aim of assessing verbal instructions on visual search strategies. They found that when provided with a conscious focus on an expert model's performance (i.e. scoring) as opposed to a focus on replicating the same expert's movement form, the participants spent significantly more time looking at the basket. Whilst it is fair to say that the instructions provided were sufficiently broad so as to permit varied interpretation and use, the group focused on shot accuracy did also outperform the body focused volunteers in free throw scoring. The implications of this work are twofold: firstly, the element of a demonstration which learners focus on may be important and, secondly, that an external conscious focus may be more effective in this applied task.

In a 2005 study specifically investigating the influence of attentional focus on performance of basketball free throws, Zachry *et al.* used a focus on the basket rim (external) or a focus on wrist motion (internal). Using a graded scoring system from 1 – 5 (5 being best) depending on the shot outcome, and with each player having twenty shots per condition, the externally focused trials produced an average score of 2.6 compared to 2.1 for the body-focused condition. Furthermore, by using a within-participants design, the researchers were able to demonstrate a relatively strong and immediate effect of conscious attention as the players changed focus. These outcomes occurred without any practise beforehand (the participants had some basketball experience) indicating that extended pre-test preparation is not necessary for external focus advantages to manifest themselves. This study also measured movement economy via electromyography; these results are discussed fully in Section 2.5.3. Weiss *et al.* (2008) found similar results in a free throw study to Zachry *et al.*'s work above. In this study, following the first 50 shots (25 under each focus condition), the researchers divided the participants up into four sub-groups dependent on their expressed attentional preference. As well as finding an external focus benefit they further report that 'forcing' an opposite focus is particularly detrimental when the prior preference is external, i.e. making an externally focused player concentrate their attention internally had a negative impact on performance.

Studies have been conducted in some other invasion games (in which all competitors play in the same area concurrently whilst trying to score at the opponent's defensive end) though, in the main and as with basketball, a discrete technique has been isolated for study rather than an assessment of attentional focus in the open skill setting common to these activities. For example, Liu *et al.* (2005) found that in an attentional focus test of players taking shots at goal in field hockey, an external focus was advantageous in transfer trials using a different shooting point; this was despite the researchers inducing anxiety by overtly filming the participants. Conducting experiments in open skills is particularly challenging due to the number of variables requiring control. Of course, in exerting such control the activity might be fundamentally changed which may render the results less relevant to the normal form. As 'openness' in sport and physical activity is so common, this is an area which should benefit from specific attentional focus research.

2.7.3 Throwing

Many sports and activities require an individual to throw an object; sometimes the main outcome desired is maximum distance, such as in athletic field events, whilst in other contexts accuracy is the main concern e.g. darts, line-outs in rugby union and juggling. There are also activities which require both force and precision such as in baseball pitching. Throwing takes place as fine motor skills requiring dexterity (e.g. darts) and as gross motor skills needing power - such as javelin. It occurs in both open and closed skill environments, for example passing a rugby ball to a teammate and throwing a discus. Several studies have been conducted examining the impact of conscious focal points on throwing accuracy, movement efficiency and force production.

Marchant *et al*. (2007) studied 67 individuals in a dart throwing task. The participants were divided into three groups (control, internal and external focus) with an outcome measure of accuracy. Somewhat unusually, the results indicated that whilst the external focus group performed significantly better than the internally focused group, the control group also performed at a similar level to the external group. An examination of the method highlights no specific reason why this may have occurred though the volunteers did report that they found the no-focus condition to be the most straightforward as the task load was much reduced. Marchant *et al.* did use multiple instructions per condition in their tests and it may be that the sheer volume of information to be absorbed and deployed in the focus conditions allowed the control group to perform so well in comparison – especially as the obvious point to focus both mind and eyes on when unconstrained is the target.

In 2011, Lohse *et al.* conducted a dart throwing task and found that an external focus was significantly more effective (less absolute error) than an internal one. In addition to this they discovered that preparation time between throws was reduced in the external condition and that muscular efficiency (as measured by EMG) was increased. Lohse *et al.* also report that kinematic[13] measures demonstrated greater degrees of functional variability under the external instructions indicating less rigidity in the motor movements. In a further dart throwing study in 2012, McKay and Wulf report that with the external focus points on either the trajectory (proximal) or the target (distal), significantly better performance resulted under the external (distal) condition. This, they explain, was irrespective of the preference expressed by the volunteers. These findings are examined further in the 'Distance' section (2.9.1).

Other throwing disciplines and activities have been utilised in attentional focus research. Zentgraf and Munzert (2009) measured juggling biomechanics in a two ball juggling task under no-focus, internal (hands and forearms) and external (ball flight and placement) conditions. The volunteers were all novices and were first shown a video of an expert demonstrating the required action from several angles. Even though no significant differences in performance were observed, they found that the focus used affected the ball flight and body movements. Interestingly, the control group's measurements were very similar to those of the externally focused jugglers leading the researchers to suggest that external focus instructions may be redundant when an effective demonstration is presented. They also argue that internal focus instructions

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[13] Kinematics originally described the motion of systems comprising jointed parts in engineering and mechanics. More recently it has also been used to describe the motion of joints and limbs in human movement – particularly in North American academic literature. Biomechanics seems to be a decreasingly used term.

may provide too much information for novices to process and thus believe this fits in with the COBALT and working memory limit explanations of an internal focus deficit relative to baseline scores. Whilst the researchers clearly state that this is a measure of biomechanical efficiency as compared to an expert, it would have be interesting to know the number of completed (no drops) trials managed in each condition, i.e. did completed juggling cycles vary with attentional focus? Unfortunately, all trials in which the balls were dropped were excluded from the data. Furthermore, no information was gleaned on what the participants actually did focus on in the control condition: it seems quite possible that they would choose a focus on the balls rather than their hands and arms which would render the finding that their performance was similar to a directed external focus less surprising – especially as the task was not particularly challenging.

Southard (2011) conducted an unusual study in which he assessed the movement efficiency and accuracy of volunteers throwing a baseball overarm at a target with their non-preferred hand. Five different conditions were used to test for the effects of an internal focus (on various body movements), an external focus (on movement in relation to the surroundings and analogous movement), an internal and external focus with the addition of a velocity focus (throw the ball fast) and a no-focus control. During the skill acquisition phase, the hypothesis that the velocity conditions would be superior was not supported; instead, the external focus group produced the most effective movement and accuracy. In retention tests five days later, the external plus velocity condition was significantly superior to all others. Southard reports that if movement kinematics is the primary objective then pairing velocity with an external focus may be most effective, whereas if accuracy is the desired outcome then using an external focus alone in practise and then applying velocity criteria to enhance retention seem the best options. This was a complex study and may need to be conducted in a simpler format before more confidence can be placed in it. Whilst it does find that both movement efficiency and outcome accuracy can be enhanced with an external focus, the instructions provided in the external condition do appear ambiguous and open to interpretation.

Using a gross motor throwing task, Zarghami *et al.* (2012) conducted a straightforward study into the effects of conscious attentional focus in discus throwing. Comparing an internal focus on the hand throwing the discus versus an external focus on the discus and its landing location, the researchers found a significant external focus benefit. Those concentrating on the discus and landing point threw, on average, over a metre further over five maximum effort attempts. With potential interest in distance of focus effects, future studies may wish to differentiate and choose between proximal and distal points – these were conflated in the external instructions here (i.e. on the discus and the target). Notwithstanding this potential development, the impact of focus on this explosive and dynamic gross motor skill is impressive; it should certainly be examined further by academics and athletics coaches alike.

2.7.4 Swimming and other continuous skills

Two studies have been conducted into conscious focus effects in swimming to date: Freudenheim *et al.* (2010) conducted two experiments, the first of which assessed 38 intermediate front crawl swimmers over a 16m distance using either an internal focus (on the hand or on the instep) and an external focus on pushing the water back (with the hand) or down (with the foot). Participants were divided so that they were exposed to either the two leg kick conditions or both arm stroke trials. The results show that irrespective of which part of the action was considered the external focus conditions were always significantly faster. In order to ascertain whether this represented an internal focus detriment or an external focus advantage, a second experiment (using only the arm stroke instructions) also included a no-focus control condition. The thirty participants were rotated through the three trials in a counterbalanced manner and again produced significantly faster swim times under an external focus; there was an insignificant difference between the other two conditions.

Freudenheim's study was, arguably, the first to use an applied, continuous skill to assess attentional effects; it implies that an external focus can be beneficial in activities which require repetitive action and effort. It should be noted though, that a single, independent individual timed the swimmers by hand; personal experience of trying to do this and then comparing my efforts to times gained using extremely accurate technological means, demonstrated that it was not possible to be either consistent or precise. When dealing with times which may only vary by fractions of a second, as in the Freudenheim *et al.* study, using suitable technology seems advisable. It is quite clear though, that split seconds can be the difference between winning and losing in competition situations, therefore an extension to this type of work is warranted and should prove informative and useful.

Stoate and Wulf (2011) ran a within-participants study with thirty competitive swimmers in a 25 metre pool. They used an internal focus on pulling with the hands, an external focus of pushing the water back and a no-focus control trial. Whilst the external focus was significantly faster than the internal condition, the control trial produced similar results to external attention. This indicates, as Stoate and Wulf point out, that avoiding an internal focus is important but that for experts an external focus may be superfluous. This does, of course, raise the question 'should coaches actually tell their charges anything about focus and, if so, what?' A survey of nationally ranked track and field athletes in the United States (Porter *et al.*, 2010a) demonstrated that 84.6% of coaches focused on their charges' body and limb movements which, in turn, led to athletes focusing internally 69.2% of the time when competing. *Post hoc* analysis in Stoate and Wulf's study, involving questioning of the participants to discover what they did think about in the control trials, discovered that they were divided between considering their bodily movements and thinking about speed. When these individuals were separated and an analysis conducted, it became apparent that those who had self-selected an internal focus were as slow as those in the directed internal condition, whereas those using an outcome goal proved as fast as participants in the external focus trial. As well as reinforcing the findings from the Freudenheim *et al*. (2010) work, in the same closed continuous skill, an additional implication raised by this study is that it may be important to not leave attentional focus to chance. As research progresses it may also become possible to provide increasingly well defined focal points (e.g. distance) and set parameters for performers which will enable them to improve. Porter *et al.*'s (2010a) research in a large sporting domain appears to show that when focus is not left to chance, current coaching practice may not be aligned with the evidence from attentional focus research.

As well as swimming, other continuous skills have also been used in research: Schücker *et al.* (2009) used a treadmill running task and found that an external focus was beneficial to movement economy (see Section 2.5.3). In a study of track sprinting Ille *et al*. (2013) found a significant benefit to both reaction time (starting) and movement time under an external focus. In line with Porter *et al.*'s (2010a) survey, the athletes in Ille *et al*.'s study reported being coached on technically correct body movements predominantly, and therefore used a focus on those whenever free to do so. Conducting more studies into continuous skills seems likely to provide a valuable extension to our knowledge and understanding of attentional effects in increasingly dynamic movements. They might also help us to understand whether external focus benefits persist over the duration of an activity and, if so, for how long.

2.7.5 Tennis and other net and racquet sports

Net and racquet sports such as tennis, volleyball, badminton and squash provide the opportunity to extend attentional focus research in several ways: they may offer the opportunity to study open skills in a controllable manner relative to invasion games, in which the main variable is the other players. They may also increase the complexity and breadth of the actions studied as, with the exception of volleyball, an implement has to be used in the game. Maddox *et al.* (1999) attempted to do just this by assessing tennis backhand shot accuracy under internal (backswing and ball strike point in relation to the front foot) and external (desired ball trajectory and landing point) conditions. Whilst the internal trial appears ambiguous as the 'ball strike point' would constitute an external (though proximal) focus, there is certainly a difference in distance between the two. The results show that the (researcher defined) external point was significantly more effective at producing both accurate shots and good movement form. What was of greater interest with this work was that the ball feed to the participants was randomised (the ball was fed by another person) so that they were unable to remain static and had to adapt to a new position on each shot. This study could be tightened by using more carefully crafted instructions and with the use of a programmable ball feeder so that all players received the same feed pattern. It is though, one of the very few attempts to examine any kind of open skill situation.

Caserta *et al.* (2007) studied the impact of a focus on decision making (perceptual-cognitive control) versus on technique (footwork) in tennis. Whilst not specifically an attentional focus study there are clear parallels in focus points. Those players who received the perceptual-cognitive training outperformed the technical group and a no-training group in both shot accuracy and decision making in live point play. In a 2013, 16 week long assessment of an external focus intervention on tennis serving amongst elite youth players, Guillot *et al.* found that after introducing externally focused instructions (target point on court and 'safety window' above net) the players improved their serve percentage significantly. Having increased successful serves by 8% in the first eight weeks they then improved a further 4% with the external focus. Whilst this could be interpreted as a continued improvement despite the attentional condition, it should be noted that the initial accuracy improvement was at the expense of velocity whereas both velocity and accuracy increased following the focus intervention. Finally, Guillot *et al.* assessed serving in match play and found a continued benefit with the external focus, in addition, they report that points won on serve (a mark of the serve quality) increased by 30%. So called 'ecological' studies like this are still rare as they are very difficult to organise and control. This does perhaps signal that long term research may demonstrate the validity of conscious focus instructions and aid in persuading practitioners of their merit.

2.7.6 Other athletic activities

In many activities it is easy to see what may constitute an external focal point as they have a target, use equipment or strike/manipulate an object. In some physical skill domains this is less straightforward as the movement patterns may be very complex and it is the quality of these which is assessed or required. Gymnastics, trampolining, dance, synchronised swimming, figure skating and diving would clearly fall into this category. How then may attentional focus be manipulated in such disciplines? Wulf (2007a, p.61) argues that if body-focused instructions can be reduced to a minimum and, perhaps, the use of analogy and metaphor increased, this may aid in maintaining a focus on the movement pathway and deflect it from conscious control of movement. She believes that this should result in the same external focus benefits as seen in other fields.

Lawrence *et al*. (2011) did attempt to examine focus effects in (relatively) novice gymnasts performing a floor sequence. The study used four matched groups under either an internal focus (on exerting an equal force on their feet, keeping their arms out straight, level with their shoulders), an internal focus (on facial muscles and expression), an external focus (on the movement pathway and to exert an even amount of pressure on the surface) and a no-focus control condition. The gymnasts were judged by professional judges against 30 criteria on their ability to perform a complex serial skill routine of starting position, lunge, arabesque, full turn and finish position. The researchers report that, whilst there were no significant differences during retention and transfer tests, during the acquisition trials with the instructions, the internal irrelevant focus on facial expression significantly improved scores whereas the external focus was detrimental to performance. This outcome is counter to the main body of research, and the list of tasks and various instructions above may hint that the complexity of the challenge provided was more prevalent than any focus created. Performing a five-part floor routine with lengthy instructions that were almost completely irrelevant to its elements whilst under formal assessment does seem to have the potential to confound the results. Notwithstanding this study, it is important that researchers do attempt to construct research which can genuinely assess focus effects in complex, artistic, gymnastic and aesthetic activities. It may be worth, for example, examining a study design that applies intermediate external focus cues in serial or continuous skills. This may provide a research 'staging post' to more complex activities.

2.7.7 Canoe-sport

To date and to the best of my knowledge, no attentional focus studies have been conducted using canoe or kayak disciplines or skills – in fact, it appears to be a field which is virtually devoid of any kind of rigorous academic research. Other than an article written over twelve years ago for the British Canoe Union's coaching magazine, extolling coaches to focus their learners' attention externally (Banks, 2001a), there has been little serious mention of attentional focus. The stimulus for the article above was the approach encouraged by the national governing organisation and their coach educators to focus on 'Body, Boat and Blade' (Ferrero, 2006). These are clearly internal and proximal focal points which, if learners are encouraged to consider them when paddling, particularly when also having to cope with a rapidly changing environment, may prove less useful and safe than an apparently more pertinent distal focus. Whilst such an approach would be similar to that being utilised by track and field coaches (Porter *et al.*, 2010), it seems at odds with the majority of attentional focus research.

The only water-sports study into attentional focus so far recorded was conducted by Parr and Button (2009) using novice rowers practising their 'catch' – the point when the blade gains purchase on the water. They report that an external focus on the oar blade versus an internal focus on body movements was beneficial to effective and efficient blade 'catch' in acquisition, retention and transfer tests. This study comprised 24 training sessions run over 6 weeks which, while difficult to control and subject to possible group cross-contamination of information between practises, does provide encouragement as to the potential longer term benefits of such a training regime. Whilst this was not a canoe based project it would certainly seem possible to replicate this type of study in a canoe or kayak racing environment with measures of either efficiency or effectiveness of movement.

Canoe-sport is a popular activity in the UK and many other countries encompassing most types of water environment, all activity, skill and experience levels and a very wide range of craft. The British Canoe Union's Canoe and Kayak Handbook (Ferrero, 2002) provides a full description and explanation of all the different disciplines and boats. Whilst most racing and other flat water paddle-sport activities take place in relatively calm environments requiring self-paced, continuous skills; due to the mobility of the sporting context the level of adaptability needed rises sharply once weather and terrain factors begin to impact on the performer. Many canoe and kayak disciplines therefore take place in complex environments with weather variables, current, other vessels, fixed obstructions, waves and other complications. Whilst there is a dearth of research using these disciplines at present, the sheer diversity of this sporting domain appears to offer many opportunities to further attentional focus study to the benefit of both canoe-sport and the wider sport and activity world.

Section 2.7 Summary

Applied studies in a wide range of physical and sporting skills have consistently found a performance, retention and transfer benefit in relation to an external focus of attention. The majority of work has used closed and discrete skills or individual techniques from more complex activities; though some studies have been conducted using closed continuous skills such as swimming and running. There appears to be significant scope to extend the research into more complex activity domains in which an assessment may be made of attentional focus effects in open and serial skills. Evidence from some sports indicates that current coaching practice may be at odds with the conscious focus suggested by the main body of attentional focus research. It therefore seems important that this field of research continues to develop and strives to demonstrate the importance and applicability of conscious focus to skilled performance.

2.8 Populations

There is ongoing debate amongst academics over the impact of conscious focus on different population groups. In the following section the more commonly discussed ones are highlighted with an overview of the pertinent research.

2.8.1 Expertise

An area which has provided 'fuel' for academic debate concerns the impact of different conscious attentional focus points on performers of varying skill levels. This field of research has engaged proponents of different academic theories: those who advocate an internal focus for novices and an external one for experts, as well as researchers who believe that attentional focus effects are universal irrespective of expertise.

Singer (2002) pointed out that experts typically demonstrate better automatic optimal functioning and self-regulation of behaviour relevant to success. This includes cognition, attention and arousal management. He highlighted that the challenge is for those less competent to attain this state. Singer also identified two potential issues for experienced individuals: firstly, that people with automated skills may be more negatively affected than novices by an internal focus and, secondly, due to effective subconscious control, experts would be able to disregard internal focus feedback and not show a deficit under those conditions. Also in 2002, Wulf and her colleagues, in a study of novice and expert volleyball players performing over-arm serves, found that an external conscious focus maintained by feedback on every fifth practise attempt, resulted in superior accuracy and movement form compared to those who received internal focus feedback; this was irrespective of expertise. Additionally, in a retention test one week later with no feedback, the external focus feedback benefit to accuracy (though not form) was found to have persisted, indicating that manipulating focus can be beneficial to learning for performers of different skill levels. This study also demonstrated that a significant focus effect can be found in a complex and applied sports skill: the only caveat being that the researchers had a list of predetermined feedback comments to deploy and several of the external focus ones did contain some reference to the body. Wulf *et al*. counter this criticism by arguing it was necessary to keep comments very similar between focus groups and had they been able to differentiate the feedback more they believe it would have resulted in a larger attentional focus effect.

Perkins-Ceccato *et al.* (2003) studied the impact of internal and external focus instructions on high and low skilled golfers performing a pitch shot. They were interested to examine the prediction from Beilock *et al.* (2002) that non-automatised skills may be less negatively affected, or may even benefit, with an internal focus on movement, i.e. that novices may find such instructions helpful. The protocols involved all participants striking 40 balls (10 from each of 4 distances) under both internal and external directions. The results showed that experts performed significantly better under external focus instructions whilst the low skilled golfers were significantly more accurate with an internal focus. This is an unusual outcome as in laboratory studies, which by their very nature tend to use novice participants, an external focus benefit is the norm for both learning and performance (e.g. Nafati and Vuillerme, 2011; Carpenter *et al.*, 2013; Wulf *et al.*, 2004). Whilst Perkins-Ceccato *et al*. claim this as evidence of a need for differentiated focal points depending on a learner's skill level, their methodology has been criticised for lack of specificity in the instructions given to the participants (Wulf, 2007a, 2013). The instructions provided asked them to 'concentrate on the form of their golf swing and adjust the force dependent on the distance of the shot' (internal); or to 'concentrate on hitting the ball as close to the target pylon as possible' (external) (p.596). In both these cases the participants are required to interpret the instructions as the parameters are so wide. For example, in the internal condition it seems quite possible those taking part might have considered their bodily movements, their club or the force to be applied or, indeed, switched as often as they saw fit. Likewise, under the external focus there was no prescription as to how they should achieve the task and what they should specifically focus on. Furthermore, the instructions were also dissimilar making them less easy to compare. Whilst participants may have focused internally and externally as Perkins-Ceccato *et al.* intended, given the range of focus possibilities in both conditions, and the likelihood that participants would select different focal points from the options available, it seems difficult to justify the claims made. Whilst there is always a possibility that participants will not follow instructions, it is quite possible to tightly define what they are expected to do, to emphasise the importance of adherence and then to question them afterwards to check compliance. Whilst not a perfect system, it may have removed much of the criticism of this study.

Wulf and Su (2007) raised similar criticisms to those above and conducted a study of novice and expert golfers (no handicap and mean handicap 1.3 respectively) chipping balls towards a target as in the Perkins-Ceccato study. In this experiment though, they defined the focus more tightly by using an internal focus on the arms and an external focus on the club. The results demonstrated a significant external focus benefit to golf shot accuracy in retention tests for the novices and, in a within-participants design, to accuracy for the experts. This led the authors to claim that, rather than an internal benefit for novices, when the instructions are unambiguous there is no reason to believe that skill level has any significant influence on attentional focus effects. As golf is concerned with striking a ball towards a distant target, it would also be interesting to evaluate the impact of distance of focus (as Perkins-Ceccato *et al*. did) to see if varying the external focus between a proximal and distal point affects the outcomes found here.

In 2004, Wulf *et al.* sought to further address the issue of tightly controlling instructions in an attentional focus experiment whilst examining differences in expertise using a laboratory based balance task. They compared the ability of world class balance acrobats from the *Cirque du Soleil* show *Mystère* with that of young adults, with no particular balance training, to remain stable on an inflated rubber disc. The acrobats, understandably, had much superior balance control compared to the non-acrobats though there was no benefit to either group of an internal or external focus of attention. Whilst the non-acrobats did not differ under any condition, the *Cirque du Soleil* performers showed a significant benefit to postural stability under the no-focus control trial. This was a surprise to the researchers; they interpreted it as an indication that highly skilled individuals may have reached such a level of automatic control that any attempt to constrain or direct their focus may result in a performance deficit. This is, once more, an unusual finding which will benefit from verification with the use of other, equally skilled, participants. It may also be useful to employ more challenging tasks to prevent a possible 'ceiling' effect whereby everyone can manage the task with ease under all conditions. Furthermore, it may have been informative to know what the acrobats did focus on in the control condition; this information was not collected.

In a study of novice and expert baseball batting, Casteneda and Gray (2007) report results that seem to support the earlier findings of Perkins-Ceccato *et al.* (2003). The researchers used four tasks with both low skilled and expert hitters in which they had to focus on either the movement of the hands (skill, internal); movement of the bat (skill, external); the ball leaving the bat (environmental, external) and auditory tones (environmental, irrelevant). In all conditions the participants had to strike a virtual baseball on a screen whilst an auditory tone was played, and also whilst they had to judge and immediately report the direction of their hands/bat or ball flight. Casteneda and Gray found that experts were significantly better when focusing on the ball whilst low skilled players benefitted most from focusing on the skill (hands and bat). The researchers argue that these outcomes are consistent with Fitts and Posner's (1967) stages of learning theory which would indicate that novices will benefit most from paying attention to each consecutive element of the motor movement, whereas experts can function effectively with fast and efficient proceduralised knowledge which does not require significant use of working memory. It should be pointed out however, that the complexity and dual task nature of the instructions used in this study may have been so challenging as to obscure any true focus effects. It is also the case that in the 'skill' conditions used, a focus on the bat would actually constitute an external focus thereby demonstrating a benefit to novices also. In order to make an accurate comparison; unambiguous, comparable and minimal instructions may have been more effective.

Beilock and Gray (2012) found, in a golf putting task, that experts regressed to a novice level of conscious control when they had to either recognise an auditory cue played whilst they putted or, when they were asked to judge at what point during a stroke a sound was presented. They also report that expert golfers were more negatively affected in the second task than novices, though the opposite was the case in the first test. The researchers again suggest that this is evidence of novices to a skill not being detrimentally affected by distraction as they are in a stage of development where they have a cognitively compartmentalised level of learning. Experts on the other hand they believe to be more prone to having subconscious control disrupted by external sensory tasks. Beilock and Gray claim these types of outcomes challenge the notion of universality in terms of an external focus benefit though, as Wulf (2013) points out, such studies do seem to be pursuing a different question, i.e. the impact of distraction on performance. She reiterates (2013, p.92) that attentional focus research is interested in ascertaining the influence of various focuses of attention on the skill in question; the introduction of task-irrelevant distractors may, unsurprisingly, undermine performance. Whether this has a greater or lesser impact on novices or experts does not appear to dictate that we should therefore provide them with differently structured information in practise; rather they should all be exposed to a method which encourages them to move to an effective level of subconscious control as early as possible. Any other approach would seem to hinder this process.

In 2013, Maurer and Munzert conducted two experiments examining the impact of familiarity of focus on performance amongst both experts and novices. Their first study used junior, national standard basketball players and showed that 18 out of the 23 participants who stated a preference for an internal focus on their body (e.g. arm, hand) performed better under such conditions. This was, however, what they had been trained to focus on and it matched their expectations both from prior coaching and due to the fact that they had to select their preferred focus before the practical task. It may have been more informative to contrast the performance of matched groups of players without influencing them with a preference in advance. This could be compared to those of different preferred focuses afterwards if desired.

In reaction to these methodological issues the researchers ran a second study examining the impact of focus familiarity on novice golfers; they again report a significant benefit to performance of using a preferred focus whereas an unfamiliar focus was not better than a control (no-focus) condition. They argue that practise with a focus to familiarity leads to automaticity that supersedes attentional focus effects. By implication, this leads to a conclusion that all coaching approaches (in an attentional focus sense) have equal value if familiarity is the predominant issue. This research has not though, fairly compared attentional focus: it does seem possible that a change to an unfamiliar method may be disruptive if it conflicts with a well established and overtly trained focus, though we do not know whether this will persist or whether an external conscious focus (which is usually superior) would allow individuals to enhance their performance beyond their current, internally focused state given time.

Ille *et al.* (2013) studied the sprint start performance of eight novice and eight expert track athletes under external (leaving the blocks, reaching the finish), internal (leg force and arm movement) and neutral no-focus conditions. They found that both groups had significantly faster reaction and movement time under an external focus and that an internal focus conferred no benefit compared to the neutral condition. Interestingly, when asked beforehand, the participants typically stated that they would think about their bodily movements during sprinting, i.e. they would self-select an internal focus. It could, of course, be argued that such questioning in advance may have, inadvertently, influenced the athletes though, if this is the case, it appears to strengthen the argument for an external focus as it overrode prior dispositions. Ille *et al*. also decided to deploy the control condition first for all participants in order to ascertain their natural approach without focus trials being able to influence the outcome. Whilst the internal and external focus tests were counterbalanced throughout, this method does run the risk of a trial order effect. It may have been better to run a no-focus pre-test first then counterbalance a control condition in a three way rotation afterwards. Despite these points, this was a true attentional focus test in which the sprinters were asked to start and run as fast as possible whilst tasked to concentrate on defined focal points. No distractions or additional tasks were presented meaning that we do have a clearer idea of how focus affects speed in novice and expert athletes.

Several other studies have been conducted in a similar vein to some of those above, wherein secondary tasks have been used to artificially force a particular focus or to assess the impact on the performers of task-irrelevant cues. Some have found that presenting distractors (often auditory tones or mental tasks such as counting backwards) have been dealt with more effectively by competent performers (e.g. Beilock and Carr, 2001), possibly, because they have working memory capacity available to manage the additional sensory input or because they are more experienced at blocking out such distractions. Other studies though, have found that interventions such as focusing on the skill during performance are more detrimental to experts, it is claimed, for the opposite reason that such interruptions interfere with their subconscious control at a critical point (e.g. Beilock *et al.*, 2002). As novices have not yet achieved this level of automaticity, such interference is deemed to be more normal and therefore less damaging to them. As Huxhold *et al*. (2006) point out, it does seem that the difficulty of a secondary task matters, and that results can vary dramatically as a function of this. Facoetti and Molteni (2000) argue that we are able to exclude distractors if we have sufficient time and, perhaps, an instructed external focus will assist in deflecting distractor effects and permit coping when time is shorter. It also appears that some studies (e.g. Ford *et al*., 2005) are not directly assessing attentional focus effects even though they may purport to be doing so, rather they are investigating the impact of a range of task irrelevant secondary tasks on skill execution, as well as a focus on the skill versus not on the skill. Whilst such distraction may be beneficial in some learning circumstances e.g. to combat an internalised focus or anxiety, Wulf and McNevin (2003) argue that it is less positive and effective than a directed external focus.

A body of attentional focus work in applied sports skills (as described elsewhere in this review) which has used participants of a range of competencies (though without comparing them directly) almost invariably finds an external focus benefit relative to internal and control conditions (e.g. Wulf *et al*., 1999, golf; Bell and Hardy, 2009, golf; Stoate and Wulf, 2011, swimming). Rather than arguing to encourage an internal focus for novices it seems more appropriate to promote a more expert approach as early as possible to foster subconscious control sooner.

> *"... it seems reasonable to suggest that actions should always be controlled at the highest possible level. This way the performer takes advantage of available motor programs that control the action automatically."*
> (Wulf, 2007a, p.149)

If this is the case why is it that research designed to directly compare different levels of expertise so often produces conflicting results? The answer to this may lie in the factors being compared and the methods being applied.

2.8.2 Age

Several studies have either directly or inadvertently studied the impact of attentional focus on different age groups. The majority of studies use suitably fit and healthy young adults who have passed through an ethical screening process in advance; the fact that most studies are conducted by university academics means that a large number of participants have been students at those establishments. The question of age has not been ignored however, particularly as there appears to be ongoing debate in education over whether children require a different approach to teaching and learning than do adults due to the progressive cognitive and neuro-physical development they undergo (see for example: Kuhn and Pease, 2006; Siegler, 2000).

Claxton *et al.* (2012) examined postural stability (centre of pressure sway patterns) in newly standing infants whilst holding a toy or not holding a toy. As it was not possible to explain or dictate a specific focus to the participants, an assumption was made that holding a toy would fixate the focus on a supra-postural task and thereby permit a comparison between this and the natural focus (or lack of it) which infants usually use. The researchers found that toy holding led to significantly improved postural stability which they interpreted as an advantage of a focus on the toy. The results also showed an increase in entropy (less regular and more complex centre of pressure patterns) with toy holding whereas Claxton *et al.* had expected to find greater stability to be linked to more physical stiffness. It would appear that the greater the natural degrees of freedom in bodily movement the more accurate and effective are balance mechanisms.

Considering that infants have a developing neuro-muscular system and a high centre of mass it is not surprising that it takes a significant amount of time before they can stand and balance within a relatively small base. Evidence that infants' balance may be aided by drawing attention to a defined external point, may indicate that stability improves when available subconscious processes are given greater control. Whilst the actual focus of such participants cannot be discerned, this study may be useful to parents and carers seeking to aid motor development in the very young. Whilst not an attentional focus study specifically, it does appear to add weight to the notion that reduced conscious control of automated processes is advantageous and being engaged by a supra-postural task may improve postural control. These results concur with specific attentional focus research into the effect on balance and postural sway which include supra-postural tasks e.g. Wulf *et al.* (2004), McNevin *et al.* (2013).

Thorn (2006) examined the balance of children between the ages of nine and twelve using a laboratory based Biodex Balance System which uses a moveable force platform to measure postural sway. Having first run a pilot to establish a level of difficulty which would avoid either a floor or ceiling effect, the participants were required to either keep their feet still (internal) or keep the platform still (external). Thorn also used a questionnaire to check what the children were thinking about during each trial as she was concerned they would not necessarily follow the instructions. This addition allowed her to filter out the participants who had not maintained the focus requested. Of those that remained, the children who were asked to focus on the platform (external) showed more effective balance performance during retention tests two days after the initial training. Children of all ages are significant 'consumers' of sports coaching and physical education; research such as this demonstrates that the wording of instructions and the focus they encourage could have significant repercussions for young people's sporting and physical activity progress and development.

Wulf *et al.* 2010b evaluated the impact of feedback on performance which led to either an internal or external focus. Using a football (soccer) throw-in task with forty-eight 10-12 year old, fit and healthy children, the researchers found that feedback which directed the participants' attention to elements of their performance external to their bodies was significantly beneficial to their movement form relative to internal focus feedback. Interestingly, this study also evaluated the impact of feedback frequency, finding unconventionally, that providing information after every attempt (as opposed to every third attempt) was more effective. The group receiving external focus feedback delivered after every throw-in out-performed all others in retention tests of form. Whilst noting that children benefitted from an external focus on the movement outcome as do other population groups, the notion that increased frequency of feedback may be more beneficial is unusual and will require further verification. Such a recurrence of intervention seems likely to interfere with learners' ability to process their own experience so as to be able to self-adjust. If this does not happen then, arguably, the provision of feedback may not be as appropriate as it could be were the coach to observe progress over a longer period and encourage the learner to 'solve the physical problem'. Whatever the optimal feedback frequency, if an external focus is deployed in this regard and coupled to information on positive and successful elements of performance, the importance of which was recently highlighted by Saemi *et al.* (2011), then more effective skill development may take place.

In 2013, Chiviacowsky *et al.* studied children with intellectual disabilities in relation to possible conscious attentional focus effects. In assessing 24 twelve-year-olds with mild intellectual disabilities (i.e. an IQ between 51 and 69) on a beanbag throwing accuracy task, the researchers found that there was a significant benefit to both retention and transfer (different target location) with an external focus on the beanbag rather than on the hand. It was particularly notable that on the transfer test the internal focus group's accuracy deteriorated markedly whilst the external group lost only a small amount of their retained performance. Whilst this is as much an assessment of individuals with intellectual difficulties as it is about children, a similar study by Saemi *et al.* (2012) of 10-year-old children with Attention Deficit Hyperactivity Disorder (ADHD) produced parallel findings. As ADHD is a childhood condition, these findings increase confidence that focus effects are relevant to this age group. It is important to note though, that young people with such challenges frequently find it very difficult to maintain attention and to concentrate on tasks relative to youngsters without this problem (Zelaznik *et al.*, 2012). If, by subtly refocusing ADHD sufferers' attention, both attentional duration and the outcomes generated might be improved; this then would be a worthwhile development for those responsible for such individuals to integrate into care and education programmes.

Older populations have also been studied from a conscious attention viewpoint: Weir *et al.* (2005) compared adults with a mean age of 70 years with a group averaging 21 years on a pursuit rotor tracking task with internal and external focuses. Using an external focus enabled the participants to keep the stylus on the light, which they had to track, for a greater percentage of the time irrespective of age. Increasing the task difficulty further exacerbated the external focus benefit, and the difference between an external and internal focus became more pronounced in the older age group. The notion that older adults may increasingly rely on an internal attentional focus and also fix their gaze more frequently on the environment they are directly interacting with is not new. Anderson *et al.* (1998) found that older adults look at the ground in front of them whilst walking more than do younger individuals. When the initial part of their view of the ground was occluded in trials, the more aged participants developed a significantly longer stride length and step velocity, i.e. that which would be associated with a younger, more confident walker. The young participants showed no alteration to their performance with the visual occlusion.

In 2006 Huxhold *et al*. compared the impact of supra-postural tasks on postural sway in young adults (mean age 24.5) and older adults (mean age 69.8). They found that the external focus generated by the supra-postural task was beneficial to both age groups though, as the level of supra-postural task difficulty was increased, competition for available cognitive resources undermined the advantage. The researchers found that the external focus benefit generated by the supra-postural task was compromised earlier for the older participants though there was a clear benefit to both groups before this point was reached compared to an internal focus on postural control. These findings perhaps match with those found by researchers who have used dual task designs in which the secondary task, or the instructions involved, are so challenging that they overwhelm any attentional effects (e.g. Casteneda and Gray, 2007).

Caserta *et al.* (2007) evaluated different attentional and training regimes in an applied sporting task, and highlighted the potentially detrimental impact of ageing on physical skill and motor control. Using 27 senior (age over 50) tennis players in Florida with an average age of 59.6 years, they trained one group on anticipation and decision making (perceptual-cognitive skills training) along the lines of Singer's (1985) five step approach, a second group were trained on technique and footwork whilst the remaining group had no training input. All groups practised equally over a five day period before testing. The results demonstrated that response speed, response accuracy and performance decision making were all significantly enhanced with the perceptual-cognitive training regime. Individuals in this group improved their response time on average by half a second; this was coupled to an increase in accuracy from pre-test to post-test of 31% to 88%. The participants also more than doubled their percentage of correct decisions in live play from 35% to 81%. Other than in response speed, in which the technique group outperformed the control (no training) participants, the technique and footwork training conferred no benefit relative to the control condition. The perceptual training resulted in a significant benefit and led the authors to conclude that the present predominance of technical training in physical activities should perhaps be challenged. There are clear parallels in this study with internal and external focus effects: clearly, a focus on tactics is distant from the body whereas a focus on footwork is, at best, very close to the body or on the body itself. The fact that these results were gleaned from older tennis players further demonstrates the enduring benefits of removing the conscious focus from the body and its movements.

Chiviacowsky *et al.* (2010) examined the effect of an internal and external focus on balance performance and retention amongst 30 older adults (mean age of 69.4 years). Whilst there were no significant differences during the initial practise phase, the externally focused volunteers significantly outperformed the internal focus group in the retention trials. Based on the percentage of time in-balance on a stabilometer over a 30 second period, the external group scored 43% compared to only 33% for the internal focus participants. It would seem that, not only do older individuals benefit from an external focus, they may actually benefit more than younger people. This may perhaps, be due to an increasingly internalised focus with ageing in order to combat the perceived and real effects of deteriorating neuro-muscular control. Hageman *et al.* (1995) explain that, when measured and compared to young adults, individuals between 60 and 75 years of age have significantly reduced postural control, response times and functional reach (the distance they can effectively reach without falling or stepping).

Laessoe *et al.* (2008) separately studied the impact of a challenging, concurrent cognitive and motor task on people of a mean age of 76 whilst walking. They report that stride variability, gait speed and trunk acceleration were all significantly disrupted and that this impact was considerably greater than in a comparable test group of younger people. McNevin *et al.* (2013) comment that older people, in general, tend to adopt a more conservative approach to bodily stability; they found in a test of postural sway whilst tackling a supra-postural task, that external focus instructions were beneficial for participants over 70 years of age. By altering the focus older people use, a significant benefit may be obtained which might have far reaching consequences for long-term mobility, activity participation, accident prevention and physical confidence.

Current evidence from attentional focus research seems to support the notion of an external focus benefit for people of all ages. Whilst the majority of work has been conducted with young, fit and healthy adult participants, these findings could actually have more significant beneficial consequences during young people's motor development and in the maintenance of physical competence as people reach a stage of life when such powers diminish.

2.8.3 Disability

An area which has proved particularly interesting is the study of attentional focus effects in people with neuro-muscular disabilities as caused by chronic and degenerative diseases such as Parkinson's and acute onset illnesses such as strokes (cerebro-vascular accidents). In effect, many of these afflictions cause an amplification of normal, age related degeneration of motor co-ordination and therefore provide a 'window' onto the impact of attentional focus at a more fundamental control level.

Wulf *et al*. (2004, Experiment 2; resubmitted for separate publication 2006) studied the balancing ability of people suffering from Parkinson's Disease whilst standing on the same inflated rubber disc as had been used to assess the *Cirque du Soleil* acrobats. This was, understandably, a much more challenging task for this group. Using a within-participants design all the volunteers were exposed to a no-focus control condition, an internal focus on their feet and an external focus on the disc. The results show a significant benefit to postural stability with a focus on the disc (external) though there was no difference between the control and internal trials. Whilst the movement frequency adjustments were faster under an external focus, there was no significant difference between the three tests. Fourier transform does commonly speed up with improved postural control, and this study shows that stability can still be much enhanced even with individuals whose physical abilities have been undermined.

The above study was followed up by Landers *et al.* (2005) when they assessed 22 individuals diagnosed with idiopathic Parkinson's disease (i.e. with no history of contributory illness and with no apparent cause) 10 of whom had a history of falls as a result of the illness. Using more sophisticated machinery than previously, each participant was assessed as before on three conditions. Whilst there were no significant benefits of attentional focus during two static balance tasks, as the challenge increased and the balance platform was made to move, there was a significant benefit with a conscious external focus on the platform. Interestingly, the volunteers who had a tendency to fall had an even more noticeable benefit to stability with an external focus indicating a direct correlation between task difficulty, motor control deficit and an external focus advantage. More recent studies into Parkinson's disease have also found beneficial outcomes when an external focus is deployed e.g. Wulf *et al.* (2009).

Also in 2005, Canning reported a study which aimed to test attentional focus in people with Parkinson's in a more normal, applied context. By asking participants to focus on either 'balancing the tray and glasses' which they were carrying whilst walking (external), or to focus on 'maintaining big steps' while walking and carrying the tray (internal), she was able to measure differences in stride length and walking speed and compare both with a baseline no-focus condition. The results show that a focus on step length produced longer strides and faster walking compared to the other two conditions (with no adverse effects on the tray's stability). In fact, under Canning's external focus condition (tray), walking performance was poorer than the no-focus control trial, leading her to suggest that the notion of directing attention to the effect of movement rather than to movement mechanics may not be appropriate for people with Parkinson's disease. In this study Canning has compared an internal focus on one task with an external focus on a different and unrelated task; this does not appear to constitute a fair test – indeed, it seems the two tasks actually confound one another. It is perfectly possible to introduce a separate supra-postural task (such as tray carrying) and monitor the impact on and of that of specific internal and external instructions directed at *either* the primary *or* the secondary task, though this was not done in this instance.

A further issue with Canning's (2005) study is that the focus instructions deployed do not seem to be tightly defined and may have actually created the opposite focuses to the ones reported, i.e. had the focus on 'maintaining big steps' resulted in a focus on covering a bigger distance with each step, rather than on the feet or legs, that would constitute an external focus; concentrating on the tray may likewise have generated a focus on keeping the hands still (internal) or keeping the glasses still (external). Whilst Canning did ask whether the instructions had been followed, she did not question the participants on their actual focus points. It does seem quite possible, under the 'big steps' focus, those taking part would have considering exactly that, and may not have attended to their bodily movements as they were not explicitly instructed to do so. If this did occur then the findings of this work could actually be construed to be supportive of an external focus both on the primary walking task and the supra-postural balancing task. Whilst the attempt to utilise everyday tasks relevant to the participants is important, choosing a single task (e.g. *either* carrying a loaded tray *or* extending stride length), and tightly defining the internal and external focus instructions on that sole issue, might have produced more clear cut results.

Fok *et al*. (2012) extended the work into the influence of attention on Parkinson's sufferers by conducting a study using a dual task design. In effect, they were interested to see if dividing attention between walking (stride length and gait velocity) and a concurrent cognitive task (counting backwards in 3s) would improve walking. Following training input on effective gait with an experimental group and, when compared to pre-test scores and the output from a control group, divided attention had a significant benefit on both stride and walking speed. This was not directly, a test of conscious attentional focus though there is a parallel in that the dual task design operates, apparently, to refocus attention away from conscious motor control (internal), therefore performance may be enhanced as a result.

As early as 2002 Fasoli *et al.* realised that assessing therapeutic interventions with stroke patients was important because they comprise the single largest population dealt with by occupational therapists and tend to receive significant amounts of input designed to help them regain motor function (Trombly, 1995). As a result of this they conducted a study comparing the response to attentional focus conditions of a healthy control group with individuals who had sustained a stroke. Using everyday movement tasks such as removing a can from a shelf or placing an apple on a table (all whilst seated) the researchers report that both the stroke patients and healthy participants demonstrated a significant benefit to movement time and peak movement velocity with an external focus of attention. This matched the outcome of an earlier study (Spatt and Goldenberg, 1997) examining attention effects in stroke sufferers and again suggests that the content and direction of verbal instruction provided by therapists may lead to significantly different outcomes for patients. Boyd and Winstein (2004) add to this following their study of individuals with basal ganglia[14] stroke in that they found that explicit instructions on the performance of a tracking task hampered the patients, whereas when permitted to use implicit processes they were

[14] The Basal Ganglia is situated at the base of the forebrain and is associated with several functions including the learning of procedures related to routines as well as some cognitive and emotional control. Interestingly, it is thought by some scientists to also be involved in action selection when we are faced with multiple cues and potential decisions. See Stocco *et al.* (2010) and Chakravarthy *et al.* (2010) for more in-depth explanation and discussion.

significantly more successful. These studies also reinforce the benefits of an external focus for fit and healthy adults.

In a 2009 study of the use of attentional focus strategies by eight physiotherapists working with stroke sufferers with a hemiplegic arm (one-sided paralysis), Durham *et al.* discovered that, of the 247 feedback comments made to patients, 236 advised or invoked an internal focus of attention. Furthermore, it was discovered that feedback comprised only a small percentage (12.9%) of the overall communication with patients and that it did not seem to follow an evidence-based format. They conclude that this demonstrates a lack of awareness of attentional focus research or an unwillingness to deploy the external focus methods which the research advocates. This finding concurs with earlier reviews conducted by McNevin *et al.* (2000) and Van Vliet and Wulf (2006) both of which found that, not only, were scientific studies having little impact on clinical practice, there also seemed to be a resistance to change despite the evidence presented.

A further area of therapy which is beginning to attract interest from attentional focus researchers is that of speech disorders. In particular, dysphasia which is either developmental (from birth) or acquired (due to injury, tumour or stroke) causes difficulty for sufferers in putting sounds and syllables together in the correct order to form words. The ability to construct appropriate syntax is often significantly undermined. Wulf (2007a) points out that therapy nearly always involves instructions which require the patient to focus internally on the movements of their mouth and tongue. Freedman *et al.* (2007) conducted a study which found that an external focus could significantly improve the accuracy with which participants could produce force with their tongue - which mirrors the studies investigating limb accuracy. The challenge now will be to move this research forwards to assess the impact, if any, on speech production and then to impress upon medical and care staff the importance of these findings for their practice and, therefore, their patients' rehabilitation.

A final study worth mentioning in this section was conducted by Porter and Anton (2011) into the effect of conscious attentional focus on geriatric patients who had been treated with chemotherapy for cancer. The authors explain that chemotherapy often causes side effects including reduced memory, diminished motor function and difficulty performing physical skills that demand visual acuity and tracking. Whilst this treatment can have a serious impact on quality of life, they note that little is known about how it produces such symptoms. Porter and Anton tested whether attentional focus conditions would affect patients' ability to manage an on-screen pursuit rotor tracking task. The results show a significant benefit of an external focus compared to both the internal and no-focus control trials. Whilst only five participants were used in this study it does demonstrate that attentional focus manipulation may be able to affect improved visuo-motor control in this population and thereby improve their lives. Work using statistically significant numbers of participants might enhance confidence in the findings.

Overall, it would appear that attentional focus research offers real benefits to patients and clinicians, though it also appears the evidence may not yet be persuasive enough, or awareness of it has not been sufficiently raised, for it to have a significant impact on practice.

2.8.4 Gender

Whilst a great many studies into attentional focus have used both male and female participants, often in relatively equal numbers and sufficient so that any gender differences might have been observed, there appear to be no reports of any such gender effects. The only study which seems to have been conducted to date which specifically examined the impact of conscious focus on separate gender groups was that of Wulf *et al.* (2003). Using a football (soccer) kicking task the researchers found that female high school students were more adversely affected by an internal focus in terms of transfer from a stationary ball to a moving ball than their male counterparts. Wulf *et al*. do not report any differences between the genders either in initial performance or in learning. It seems that insufficient evidence exists in general to claim any differences between the genders in an attentional focus sense, though there is an opportunity for further work to be done to elucidate this question.

2.8.5 Attentional preferences

From the point of view of attentional focus studies, some have included learner choice and preference as part of their methodology. These studies were based on the premise that performers develop their own attentional preferences and using these may be superior to externally applied focal points. This is not an unreasonable hypothesis, as experts in particular, could be expected to have optimised their focus over hundreds or thousands of hours of practise and performance. With these questions in mind an early study was conducted by Wulf *et al.* (2001, experiment 1) in which they introduced participants to an internal and external focus on the stabilometer and then allowed them to select one or the other for a second session of testing the following day. Whilst the majority (10 out of 17) initially preferred an internal focus on the feet and used it for session two, during the retention test on the third day half of the internal preference participants switched to use an external focus on the platform. Most importantly, those who did adopt this external focus produced significantly better balance performance than the internal focus group. This seems to suggest that initial preferences may have been based on intuition or expectation and that, having experienced the two, even with such a small difference in focus, the majority chose the external point and benefitted as a result. Experiment 2 in this study provided 20 individuals the opportunity to try both focus conditions and switch as often as they wished over two days; 16 then decided that the external focus was their preferred and, on testing their balance, those who selected this approach had superior stability. These results show that, given time, learners may be able to discern a more effective focus though this is not universal or guaranteed. What is apparent though is that an external focus is still more effective for all those who choose it no matter what percentage do so and irrespective of their initial preference.

Marchant *et al.* (2007) ran a study into dart throwing performance under external, internal and no-focus conditions. Afterwards, the volunteers were asked to rate the effectiveness of the instructions and, by a significant margin, believed the external focus to be the best. As this was a between groups study the participants did not have the opportunity to compare conditions, yet were still sensitive to the benefits of an external focus. The external trial was also the most effective in terms of dart throwing performance. Weiss *et al.* (2008) and Weiss (2011) ran studies in which volunteer dart throwers were asked to perform using their non-preferred focus. In all cases those being 'forced' to switch from an external preference to a non-preferred internal method suffered the most significant decline in performance. Ehrlenspeil *et al.* (2004) found a similar effect in a study on billiards players. They report little difference in accuracy and consistency between focus conditions but noted a performance decline in a second stage of testing which required participants to use the opposite focus to the one they preferred. Whilst a 'forced' external focus was inconsequential, requiring externally focused players to use internalised attention significantly hampered their billiards shots. It does seem possible then, that forcing a switch of focus may be detrimental whichever direction it is in, at least in the short term with individuals who have a well-established approach, though changing to an internal focus seems to be most inhibitory and has the additional detriment of being less effective in the first place.

Kasper *et al.* (2012) sought to examine whether individual differences in attention strategy influence the effect of an internal or external conscious focus.

They found that pre-existing attention, as tested in a visual attention task, was predictive of enhanced golf putting performance though only under an external focus of attention. The researchers contend that understanding learners' prior attentional abilities may aid in explaining motor performance in a novel task. The finding that an external focus was beneficial is, they state, supportive of the Constrained Action Hypothesis. This is an interesting and novel study though the instructions provided to participants in the two focus conditions were very lengthy and also open to interpretation. For example, two of the five internal focus directions 'Position your feet so that the ball sits between them and in front of you' and 'Finish with arms pointing straight in the direction of the target' (p.1166) could lead to a focus on the feet or the ball, or the arms or the target respectively. Not only might this generate several internal or external focus points, the external one may vary in distance from the participant and they are also being encouraged to switch focus between multiple points. When trying to assess the impact of attentional focus against other variables, such as prior attention strategies, study outcomes may be more reliable and trustworthy if the instructions given to volunteers are more tightly controlled.

In a study previously mentioned, Maurer and Munzert (2013) studied the impact of conscious focus on expert basketball players and cross-matched this with their preferred focus of attention. Assessing focus predilections in advance, the researchers found that familiarity was important in that those who stated, for example, a preference for an internal focus, performed better under those conditions. There are though some potential issues with this finding such as the fact that the participants were asked to choose their preferred focus (on the task to be used) in advance of being exposed to the trials. This seems to increase the chance of the players then being pre-programmed to differentiate their effort and expectations when faced with the tests. It may also have been the case that they had been trained and expected to use an internal focus so this was the focus they were expert in. In addition, and as with Kasper *et al.*'s (2012) study, the focus directions consisted of multiple statements, though in this case, the participants chose ones which they most associated with, meaning that individuals had different focuses during the trials. Perhaps a better way of structuring this study would have been to either identify sufficient volunteers of a matched standard, so that an external and internal preference group could have been tested against a tightly controlled and comparable version of each focus condition or, they could have tested all the players and then evaluated their preferences after the event.

In a second experiment in this study, Maurer and Munzert addressed the issue of expertise and prior awareness of focus. Using a golf putting task with novices they report again that familiarity with a focus was more effective under both internal and external focus conditions than an external focus under any conditions. They tested this by requiring the participants to count audible tones whilst putting as accurately as possible under both familiar and unfamiliar internal and external focus instructions. Rather than attentional preference being tested here, an alternative explanation for the outcome could be that automatised skills are more resilient to a task-irrelevant distractor.

Methodological matters notwithstanding, the issues of attentional preference and prior attentional training are still ones which offer room for further investigation. At present though, it seems that even if these factors do play a role, the influence of directed conscious focus may be more potent.

Section 2.8 Summary

Section 2.8 demonstrates that an external attentional focus benefit is prevalent across different populations. Whilst the issue of expertise is proving more challenging for researchers, studies of age, disability, gender and attentional preference have produced more homogenous findings.

2.9 Research extensions

This section will deal with two areas of work which do not fit within the previous categories. They do though appear to be critical to future understanding and to offer avenues for considerable ongoing research.

2.9.1 Conscious focus distance

The vast majority of studies in this field have maintained the internal and external focal points very close together (e.g. Wulf *et al*., 1998; Freudenheim *et al.*, 2010). This provides several benefits: it assesses whether even a small and subtle difference in focal point can affect performance; it also means that instructions can be very similar. This avoids the potential for differences in tasks and information obscuring or confounding any attentional effects. In normal activity and sports however, it is obviously the case that people vary their focal points and will often subconsciously select ones which are distant from their body – indeed it may be advantageous to do so.

With this issue in mind researchers have investigated the influence of distance of external focus to see if the effect varies the further from the body it is. Wulf (2007a) comments that early studies indicated there may be a distance effect and this may not only be in the size of the external focus benefit but also on the speed with which it takes place and the retention which it engenders. She points out that experiments in which the distance between the focal points was very small often demonstrated an external attention benefit in later retention tests (Wulf *et al*., 1998). Additionally, when using applied studies, for example in golf, effects were produced which were more pronounced and occurred more quickly (Wulf *et al*., 1999; Wulf and Su, 2007). McNevin *et al.* (2003) argued that by moving the focus further away we are able to distinguish it more from our bodies. An additional explanation might be that remote focuses are more natural and normal, which may mean that they are closer to an optimal distance. It certainly seems that we would not commonly focus on our bodies when performing automated skills in a subliminal manner. Proponents of a dynamical systems view (e.g. Shumway-Cook and Woollacott, 2007; Hodges and Franks, 2000) would point to the necessity of a focus on an appropriate environmental point as it permits the action and perception link to be maintained during skill execution.

McNevin *et al.*'s (2003) stabilometer study, in which they used three different external focus points on the platform (to the outside of the feet, between the feet and immediately in front of the feet), resulted in the 'far outside' and 'far inside' points producing better retention and superior postural control compared to the 'near outside' mark. Park *et al.* (2000) chose to use even more distant markers on the stabilometer (approximately 1 metre); though in this study he placed them in front of the participants – which seems to be a more natural point for people to focus on. Balance performance was enhanced even more with this increased distance. It should be noted that in both these studies that visual attention was controlled by requiring the volunteers to observe a fixed point on the wall ahead of them during all trials.

In 2009 Bell and Hardy constructed a study to examine the impact of anxiety and focus distance on the accuracy of skilled golfers. The researchers introduced anxiety by informing the volunteers that they were being videoed so that their performance could be assessed by a professional; they also provided a sizeable cash incentive for the most improved player. The results showed that, irrespective of anxiety, the distal external focus (on the ball's flight) produced significantly higher accuracy scores; the internal focus condition (on the arms) produced the poorest performance. McKay and Wulf (2012) used dart throwing to further examine distance effects. Participants were tasked to throw with a focus on either the dart's flight or on the bull's-eye (target). The results showed a significant benefit for the distal versus the proximal focus. This further demonstrates the importance of a focus on the point aimed for – the ultimate outcome of the movement – and, in effect, took Bell and Hardy's distal focus and adopted it as the proximal one.

Porter *et al.* (2010b) found that comparing internally focused standing long jump performance with an external focus to jump as far past the start line as possible led to significantly superior jump length. Wu *et al*. (2012) used the same laboratory jumping task and discovered that, whilst the external focus was much more effective than the internal focus, the difference in peak force generated against the ground was insignificant – in fact the external focus had a slightly lower peak force. This means that the participants jumped further with less force. Porter *et al.* (2012) followed this up by removing the internal trial and adding an additional, and more distant, focal point. They found an immediate and considerable improvement in performance with the use of the distal focus: this distant condition averaged 213 centimetres which was six more than the proximal focus and seventeen more than the no-focus control trial.

A final study worth including is one conducted by Stoate and Wulf (2011) evaluating the impact of conscious focus on experts' swimming speed. An internal trial ('pull your hands back') was significantly slower than both an external focus ('push the water back') and a no-focus control condition though, interestingly, there was no significant difference between the latter two. On questioning, some of the participants explained that in the control trial they had focused on specific body parts whereas the rest had focused on an outcome –

such as speed or reaching the end of the pool. *Post hoc* analysis of these two sub-groups revealed that those who had focused on an outcome in the control trial had significantly faster times than those who had selected an internal focus. The results suggest an internal focus is detrimental whether self-selected or externally applied and, in the case of individuals with a highly automatised skill who use an external focus, that additional external focus directions may be superfluous. It may also be the case that it was the specific distal focus (on the outcome) which permitted these individuals to perform as well as with the directed proximal focus. Had a distal focus been applied and more tightly controlled it may have produced even more interesting outcomes.

When the complexity of many, if not most, human movement environments is taken into account and, in particular, high paced and complex open skills are considered, it seems that a conscious focus on distal points will be required and may need to constantly switch to be most effective. With this in mind it seems that distal focus research is an undeveloped field; there appears to be significant scope to extend attentional focus study into a wide variety of movement and other fields to try to elicit optimal focuses under a range of conditions and in different contexts.

2.9.2 Skill type

The majority of attentional focus research to date has been conducted with either closed and simple discrete skills contrived in a laboratory setting (e.g. Nafati and Vuillerme, 2011; Shea and Wulf, 1999; Zachry *et al.*, 2005, Zentgraf et al., 2009) or with the use of similarly self-paced and discrete elements of standard physical activities, for example golf chipping and putting (Wulf *et al*., 1999; Perkins-Ceccato *et al*., 2003; Bell and Hardy, 2009). In some, far less common, cases, closed continuous skills have been examined (Freudenheim *et al*., 2010; Stoate and Wulf, 2011; (swimming); Schücker *et al.*, 2009; Ille e*t al.,* 2013; (running)). It is completely understandable why researchers would choose to do this as they need highly controllable environments so that they can weigh the consequences (or lack of impact) of their experimental manipulations. To not do so would risk the effects of any independent variables being obscured or confounded by uncontrolled and potentially influential factors. Some studies have sought to assess the impact of distractors and dual tasks which are both relevant and irrelevant to the central task, for example Jackson *et al*. (2006) and Beilock and Gray (2012). These may indicate which focus is more effective in an environment when multiple demands are made on the sensory, cognitive and motor system though in normal, externally paced skills there is rarely only one variable and those that are present are often irregular. As has been reported throughout this literature review the general outcome from well designed and managed studies using a range of environments and activities, is that a conscious external focus is advantageous to performance and learning (see Wulf, 2007b; Wulf, 2013).

The class of skills which are conspicuous by their absence from the literature are open skills. By their very nature these externally paced skills are difficult to control which, in the main, means that academics may not try to investigate them and, instead, extrapolate findings from contexts which are sometimes quite different. In the case of attentional focus in open skills, it seems that a conscious focus on the body may be detrimental or even dangerous, as it acts to draw the performers' attention away from the ever changing environment with which they have to interact. Imagine for example, riding a motorcycle whilst concentrating on hand pressure on the brake lever (internal) or on the number of degrees the handlebars have to be turned (proximal) to safely negotiate a corner. One or two studies have been conducted which have used complex activities: Masters *et al*. (2008) examined learning and retention in a time constrained environment. Using a standard table tennis table and by employing a mechanical ball feeder, participants had to strike thirty balls per minute to set targets as denoted by the colour of the ball (white or yellow). They found that the players, who had been trained using an analogy method (which the researchers believe to lead to subconscious control) as opposed to those who had been coached with explicit instructions, were significantly more competent when task complexity was increased. The results suggest that implicit (subconscious) learning allows performance to remain stable under pressure. Whilst this is not directly related to attentional focus there is a clear parallel in that the argument against an internal focus is that it interferes with and constrains the body's subconscious, implicit control mechanisms.

Masters *et al*.'s findings do also mirror those of Caserta *et al.* (2007) who found that senior tennis players demonstrated greater accuracy and more effective decision making whilst playing live points if they had been exposed to perceptual-cognitive training as opposed to technical instruction. In a further tennis study, Maddox *et al.* (1999) found improved backhand accuracy using an external focus whilst balls were fed in a randomised manner. Using a computer simulation to replicate driving a racing car, Mullen *et al*. (2012) were able to introduce a high speed and competitive activity to the laboratory. They found that a distal external focus produced significantly superior driving performance than an internal focus; it also resulted in reduced heart rate variability. Artificial tasks such as Mullen *et al*.'s do provide a 'window' onto complex skill performance and conscious focus though, without using full scale simulators, they cannot replicate the neuro-motor control required in an applied physical skill, or measure the attentional focus impact on its performance and retention.

Open skills then seem likely to be a particularly fertile area for study in relation to conscious focus, not least because the majority of activities and skills which we have to perform do have an element of variation in them which has to be adapted to. From a research point of view the difficulty lies with selecting an activity in which functional variation can be maintained but also one in which this variability is consistent. Without this no fair comparisons can be made and no valid claims established. Developing an understanding of attentional focus in open skills, particularly if they are normal, physical activities and sports seems likely to be an interesting and informative avenue of research.

Section 2.9 Summary

The distance of an external focus appears to play a significant role in its effect though there is scope for development in this field to optimise focus distance in different circumstances and with different groups such as novices and experts. Most attentional focus research has used discrete and closed skills, whilst these have often been relatively complex, moving the research into open skill domains would be a valuable development which seems likely to interact with focus distance.

2.10 Summary

In my efforts to demonstrate the breadth of attentional focus research: the concepts, the debates and the range of outcomes, I have, perhaps, made it appear that there are inconsistencies in results, conclusions and implications to a point where there is no general consensus. It is, however, fair to say that the less common outcomes may have received a disproportionate amount of attention in this review by virtue of the fact they are reported and discussed even though they represent a much smaller percentage of the body of research.

As Wulf (2013, p.80-82 and p.85-86) explains and demonstrates in tables of the research done - along with their main findings as published by 2012 - eighty or more studies that have used comparable attentional focus conditions and instructions have found an external focus advantage. Only a handful did not and none found an internal focus advantage. The studies which have found unusual results, insofar as they do not match the bulk of output, frequently seem to have confounded their data by using overly complex and lengthy instructions or by providing directions which were ambiguous and open to interpretation. Others have utilised secondary tasks which appear sufficiently challenging to be likely to disrupt performance whatever the focus conditions. Beilock and Carr's (2001) assertion that novices benefit from an internal focus which permits them to attend to new skills in a staged manner, has used experiments which are not actually examining internal versus external focus on the same skill. Rather they are assessing a focus on the skill versus not on the skill without differentiating between internal and external points. It is unfortunate that results from such work are commonly seen as contradicting internal/external attention studies when it would seem that research testing the Explicit Monitoring Hypothesis is actually pursuing a different line of enquiry.

To date, research into the effects of conscious attentional focus has utilised laboratory based investigations into skill acquisition and performance (Wulf, 1998), learning (Wulf *et al*., 1998), feedback (Shea and Wulf, 1999), transfer (Totsika and Wulf, 2003), reaction time (Wulf *et al*., 2001), supra-postural and dual tasks (Nafati and Vuillerme, 2011), task difficulty (Wulf *et al*., 2007) and external focus distance (McNevin *et al.*, 2003). Most, if not all of these issues have also been evaluated in a wide range of applied contexts such as golf (Bell and Hardy, 2009), basketball (Maurer and Munzert, 2013), swimming (Stoate and Wulf, 2011), tennis (Guillot *et al.*, 2013) and darts (Lohse *et al.*, 2010), though in these and the other activities used, the greater part of the work has been with closed, discrete skills. The few exceptions have been with a small number of swimming and running studies in which continuous skills were used (e.g. Schücker *et al*., 2009, Freudenheim *et al*., 2010). Serial and open skill studies are lacking, perhaps due to the logistical difficulties involved and the challenge of controlling variables. In addition to the above work separate populations have also been assessed such as differing levels of expertise (Perkins-Ceccato *et al*., 2003), children (Thorn, 2006), older age (Chiviacowsky *et al*., 2010), disability (Landers *et al*., 2005) and attentional preference (Marchant *et al*., 2007).

Further to these studies, attentional focus research has gone to considerable lengths to assess and understand psychological, neurological and physiological bases and effects. To that end work has evaluated the impact of conscious focus on anxiety (Jackson *et al*., 2006), alpha-wave emissions (Radlo *et al*., 2002), Fast Fourier Transform (McNevin and Wulf, 2002), heart rate (Radlo *et al*., 2002), muscular activity (Zachry *et al*., 2005), movement kinematics (Wulf *et al*., 2010a), force production and muscular endurance (Marchant *et al*., 2009), force accuracy (Lohse and Sherwood, 2012) and respiratory control (Hessler and Amazeen, 2009). The vast majority of the studies above have demonstrated enhanced movement efficiency (e.g. muscular activity, heart rate and endurance) as well as improved movement effectiveness (e.g. balance, accuracy and speed) with an external attentional focus.

Whilst attentional focus research stemmed from motor learning in sport, this should not be seen to constrain its applicability or to limit studies to athletic contexts. It seems vital that this knowledge and work is brought to bear in any environment where we seek to acquire physical skills. Many people do not have the time, money, interest, facility or opportunity to take part in sports; this does not mean, however, that this field of study cannot impact on their lives in a beneficial way. Research into therapeutic applications (e.g. Fasoli *et al*., 2002) and the playing of musical instruments (e.g. Duke *et al*., 2011) are examples of steps in that direction. Many strands of potential study still present themselves as does the opportunity to reinforce and challenge current evidence. In particular, developing research to clarify attentional effects amongst novices, young children and individuals with disability and illness will be helpful. Extending the research into other environments and domains such as the work place, schools, the home, the outdoors or wherever it may be deemed informative, appears likely to demonstrate the generalisability of attentional effects and the usefulness of this work to non-sporting contexts.

As Wulf (2013, p.98) points out, the neuro-motor and behavioural effects of external and internal conscious focuses appear consistent and clear. Further studies into neurological correlates with the different attention points should assist in the comprehension of the underlying mechanisms involved. More work also needs to be conducted into attentional effects on movement form and into activities which are judged by form. To date, most studies have used discrete skills in both laboratory or applied settings; extending the research into more complex movement environments such as serial and open skills seems particularly pressing. The issue of optimising distance of external focus is also an undeveloped field which requires significant work.

Whilst the underlying psychological and neuro-motor mechanisms are, as yet, unresolved, the external conscious focus advantage appears to be a robust and persistent performance and learning phenomenon. Anecdotal evidence suggests that this knowledge is having little if any impact on coaching practice in the field as the inertia of theory and methods proves resistant to up-to-date information and change. In a broader sense, the potency of attentional focus effects are likely to be able to influence learning and performance in the full range of physical movement and other skills that we all engage with during our lives. The evidence is increasingly compelling and, whilst the findings need to be more effectively communicated so the potential benefits may be shared by all, development is still required via future well designed research which addresses the gaps in current knowledge. The ensuing studies in this thesis will, hopefully, contribute to that process.

Chapter 3

Research Methodology

3.1 Research question

Based on the review of literature in Chapter 2, it has been possible to revise and clarify the research aims identified in Chapter 1 (Section 1.5.1). The question I now intend to investigate concerns the *distance* of an external conscious focus in continuous open skills. Specifically:

> Is there an impact on timed performance in applied open continuous skills of a proximal, external focus versus a distal, external focus as compared to a no-focus control condition?

3.2 Research rationale

The literature review and previous pilot study demonstrate that there are several research avenues available to extend knowledge as well as to expand current work. The case for an attentional focus benefit to initial skill acquisition, retention and transfer of learning is well made (e.g. Wulf 2007a, 2007b, 2013), though the external focal point used in studies has typically been proximal to the performer (e.g. Freudenheim *et al*., 2010; Zentgraf and Munzert, 2009). Also, perhaps due to the difficulties of controlling variables in applied settings, a limited range of real-life sports and other physical skills have been examined, and these often in a contrived or altered manner. The activities which have been used have tended to be discrete techniques (a single action with a clear beginning and end) in a benign (closed skill) setting (e.g. Zachry *et* *al.*, 2005; Wulf and Su, 2007; Lohse, 2012). It therefore seems that an informative path to pursue would be to examine the interaction between different, specified external focal distances and compare the impact of those to control situations in which no conscious focal point is provided – thereby assessing the effectiveness of participant selected points in relation to those dictated by experimental conditions.

The initial objective of this research therefore, is to evaluate the impact of attentional focus in an applied, open skill setting. The motivation for this being the significant volume of robust evidence built up since the mid 1990s (see Wulf, 2007b, 2013 for reviews) which has rigorously demonstrated the beneficial impact to learners of moving their conscious focus away from the body and onto a point slightly further away. This proximal, external focus (e.g. on the golf club rather than the hands and arms) has consistently been found to be more effective in generating improved performance, retention and transfer (e.g. Schücker *et al.*, 2009; Totsika and Wulf, 2003). In addition, trying to establish the above relationships by utilising real-life sports skills and environments may assist in making any findings more transferable to applied coaching and learning situations. An extension of the current body of knowledge to ascertain the impact of different external attentional focal points in continuous open skills should be of particular interest. Practitioners may also be more likely to take heed of evidence that provides such ecological validity.

The occasions when an external focus advantage has not been the case are few, though one such study does stand out. *Cirque du Soleil* acrobats performed significantly better in a no-focus control condition relative to both an external, proximal condition and an internal focus condition (Wulf, 2008). The task involved expert balance acrobats standing on an inflated rubber disc whilst postural sway and corrective movements were measured. Unusually, there was little difference between the directed focus conditions whilst the focal points selected by the performers in the control trial significantly enhanced their balance. Whilst it is common in attentional focus research to use a control condition to assess the difference between the experimental factors, as well as against individuals who are given no information on how to tackle the task, until Wulf's (2008) study it was uncommon when assessing expert performers. In this case it permitted the study to ascertain whether or not the experimental conditions conferred an advantage relative to one another but also, critically, in relation to no specified focus as it is possible that experimental conditions could produce a performance disadvantage too. Usually the external, proximal focus is superior to both the others but in this case the control condition was significantly more effective – neither internal nor external proximal focus provided a performance advantage to the acrobats.

Whilst the *Cirque du Soleil* participants were not asked what they focused on in the control trial it seems reasonable to speculate (based on the fact they have to complete complex movement patterns very accurately at speed in relation to other acrobats and objects) that their preferred focus was even more external –

a distal, external focus. This may mean that they concentrated on higher order outcomes which could be subconsciously controlled e.g. standing still as opposed to thinking about their feet or the disc. Performers at this skilled level seem likely to automatically select an appropriate focus for their task which may even switch between factors they deem to be important. Furthermore, it seems reasonable to predict that those taking part in open skills, in which they have to constantly evaluate the environment around them so as to be able to anticipate, react and respond as effectively as possible, need to have a distal, external focus for a high percentage of the time. In the case of the study above, interviewing the acrobats to ascertain the focal points they used would have provided interesting and potentially valuable information.

The above research suggests the need for an extension of the attentional focus work into realistic, applied settings so that, rather than simply reinforcing the evidence that an external, proximal focus is superior to an internal focus (commonly with novice performers and undergraduate students), the optimal focus may also be evaluated. This may prove more useful to learners and coaches alike, particularly if tangible and applicable sports specific evidence can be provided to those working in the field.

3.3 Constructing the research 'landscape'

Bearing in mind the practical and academic limitations previously mentioned, it is problematic indeed to construct an applied study in a controlled sporting environment without undermining the real nature of the activity – particularly if the sporting skill studied is an open one. As virtually all previous studies have researched an internal versus an external focus in laboratory tasks (e.g. McNevin and Wulf, 2002), isolated technical elements of complex skills in a benign setting (Casteneda and Gray, 2007) or tightly controlled discrete and closed skills (Wulf *et al*., 1999), there appears to be plenty of scope to extend research into more applied and realistic activity situations. The difficulties mainly relate to effective control of the large number of potentially confounding variables. This experimental and logistical challenge may be a factor in deterring or preventing research in truly applied, open skill settings. Paradoxically, whilst experiments in such an environment are much harder to control and may be open to greater criticism from a scientific rigour point of view, they may be given greater credence by teachers, coaches and learners who are able to relate their work more directly to the output. This then indicates a need to construct any studies in as robust a manner as possible so that any findings and guidance are based on rigorous methodology. There is ample evidence that intuitively appealing educational methods which have no underpinning, scientific evidence base are able to invade practice and to become embedded in such a way that challenging and removing them becomes extremely difficult (Greenfield, 2007; Leevers, 2014). For example, reviewing literature pertaining to 'learning styles' and the, so called, Meshing Hypothesis, identifies just such an issue (see Coffield *et al*., 2004a, 2004b; Pashler *et al*., 2009, Reiner and Willingham, 2010).

Notwithstanding these challenges, the aim of this thesis is to design research to examine the interaction between a proximal, external focus and a distal, external focus versus a control condition in an applied open continuous skill. There is no evidence apparent in the literature to suggest this has ever been attempted before. Wulf (2013) provides tables of all the attentional focus research conducted up to and including 2012; these demonstrate that a small number of studies have included a distal focus (e.g. Bell and Hardy, 2009; Porter *et al*., 2012) though this was instead of a proximal one. Others have examined continuous skills though these were in a closed context and typically used a proximal and internal focus (e.g. Freudenheim *et al*., 2010; Ille *et al*., 2013). An even smaller number have used open skills (e.g. Maddox *et al*., 1999; Masters *et al*., 2008; Mullen *et al*., 2012) though these have all employed adapted or simulated situations.

The immediate and obvious issues with designing an applied study (or studies) are in choosing an activity and context which would provide a consistently varied environment though without altering or adapting the normal application of the task. This seems to rule out all invasion games and, indeed, all sports in which the main environmental variable is other people (e.g. opponents, team mates, officials, spectators) due to the difficulty of maintaining consistent conditions. The open skills remaining are such because they take place in an environment which itself physically varies to some degree e.g. skiing, cycling, canoeing, surfing, rock climbing etc. and this environmental variability is the predominant factor interfering with the participants' ability to perform. In addition, and importantly, in the examples above the main variable directly and physically impacts on the participants thus making the activity more externally paced. This therefore requires more rapid and accurate responses[15] in order to be effective. In the case of the examples above, 'openness' is increased by the complexity and speed of change of the environment in which the activity takes place so, for example, kayaking on very complex and powerful white water is a particularly open skill. The ability of any individual to perform in such an environment has no influence on its 'openness' – those taking part are just more or less skilful.

The types of open skills described above are more attractive from a research point of view as they require no organisation of multiple performers simultaneously or the setting up of elaborate, contrived or overly simplified situations. The challenges surround choice of activity and the finding of an environment which maintains natural 'openness'. Such a situation needs to remain stable across participants and trials so that fair comparisons can be made and the impact of extraneous variables controlled. Finally, the research environment must be one in which safety can be maintained and consequences are manageable.

[15] Response time is the sum of reaction time and movement time. Reaction time begins when a stimulus is detected by the senses and ends when movement starts. Movement time is from the beginning to end of movement. The more 'open' the skill the shorter the response time available.

3.4 Variables

It is clear from the outset, and as a result of the previously conducted pilot study (Banks, 2009), that to attempt research in applied contexts – especially when using open skills – will require thorough identification and control of potentially confounding variables. The following variables will require containment depending on the experimental demands encountered.

3.4.1 Participants

In order to permit generalisation of results to participants in the research activity as a whole, as well as to those attempting to acquire skills in a broader range of sporting and activity contexts, it is important to ensure a representative sample of participants is used. Available controls include inviting performers from the broader population and avoiding testing sub-sections of society. In order to ensure sufficient competence to produce meaningful data a minimum standard of participant skill will be required in all experiments.

3.4.2 Environment

Any variable which may impact on the performance of participants needs to be controlled. For example: direct and indirect distractions such as other people, inconsistent conditions, experimental paraphernalia and wildlife.

3.4.3 Equipment

All equipment which could have an impact on performance if varied between participants needs to be standardised. This includes both activity and testing equipment. When such homogenised equipment may hamper participants (e.g. due to poor fit or incorrect sizing) then using personal gear which fits appropriately and which does not confer an advantage will be permissible.

3.4.4 Modelling

During any experiment in which the ability to copy and imitate others may provide a performance advantage such modelling needs to be prevented.

3.4.5 Information

Information needs to be controlled in a variety of ways to ensure consistency across all participants. Prior information must provide the same overview of the practical requirements of the individual studies to potential participants so they are able to make an informed choice concerning their participation. It is critical though, that it should give no indication of the experimental aims and objectives as to do so may cause them to act in such a way (either consciously or subconsciously) which may alter their performance. Specifically, any effects which may affect the participants' performance due to their preconceptions or desire to be helpful needs to be prevented (Rasmussen, 2008; Rosenthal and Jacobson, 1968).

During the experiments all volunteers need the same participant information and they must all provide written informed consent. Passing of information between participants should be controlled by careful timetabling to avoid any overlap of attendance. In addition to this, it is also necessary to ensure all those taking part fully understand the importance of not discussing any part of their experience with anyone else to avoid contaminating future participants' performance. Gathering of any information from participants on their performance will need to be done using a standardised recording process and the use of open and non-leading questions. Finally, in order to prevent any influence on future participants, none of those taking part should be permitted any feedback or information concerning their performance or the nature or purpose of the tests following their trials. They should be informed that the data and results will be available in the future following the conclusion of the project.

3.4.6 Study structure

As the proposed research requires the comparison of participant performance under different attentional conditions, there are some alternative approaches available to maintain rigour in the experiments.

3.4.6.1 Between-groups (matched groups)

If using between-groups designs with relatively small numbers in each group, it may be necessary to pre-test, rank order and then quasi-randomly allocate the participants to experimental groups to ensure appropriate balance and accurate comparisons. As the number of participants rises random allocation is sufficient as the probability of significant differences between the groups caused by individual differences diminishes (Field and Hole, 2003, p.71 explain approaches to randomisation). A between-group method requires a sufficient number of volunteers per group to make any analysis statistically significant – this factor may limit the number of conditions (groups) which can be compared. If retention and transfer tests are employed they need to be at a fixed later time point beyond the initial performance tests. These can only be conducted if a between-groups design has been implemented as the separate groups will not have been cross-contaminated by experiencing more than one condition. The implications for the proposed studies in this thesis are the difficulty of finding sufficient suitable participants and then timetabling them for multiple tests with fixed time intervals. This is logistically challenging with such limited research resources – an issue compounded by the potential participants' varied personal situations and availability. If this method is utilised, it will remove the possibility of trial order, fatigue and training effects which may occur when using complex aerobic physical skills, as each participant takes part in only one condition. Between-groups designs are also able to produce data on the immediate *and* longer term effects of the experimental manipulations which may make the findings more useful to participants and coaches. Field and Hole (2003, p.75-79) provide an overview of between-groups designs and their strengths and weaknesses.

3.4.6.2 Within-participants (repeated measures)

In the case of a within-participants design, in which all participants are exposed to all conditions, it is essential to counterbalance the trial order so as to avoid any 'carry-over' effects (Harris, 2008, p.157-161). No retention or transfer tests can be run if this design is adopted, only initial performance can be measured. Participants will need to be allocated to the next available order as they attend so they could not be allotted a configuration in advance which may produce any particular outcome. This approach has the advantage of gathering data from each participant under each condition and therefore requires fewer participants (or permits the gathering of more data). However, it does also mean that strict protocols need to be enforced to avoid contaminating the results. *Post hoc* statistical analysis can be used to ascertain any trial order, training and fatigue effects (carry-over effects) which may confound the results. The repeated measures design does have a further important benefit: it removes the random variation present when comparing different individuals as in the between-groups approach and is therefore more sensitive to the experimental manipulations deployed (Field and Hole, 2003, p.80). In relation to the proposed studies in the present thesis, this method is less challenging logistically and produces three times as much data per participant as the between-groups approach (based on three experimental conditions). Whilst it will result in data only being gathered on initial performance, it does ensure equal amounts of data for every trial. This method may be better suited to the resources available in the present work and make the demands of timetabling participants far more manageable. See Field and Hole (2003, p.79-86) for comprehensive information on within-participant designs, including the advantages and disadvantages of their use.

3.4.7 Fatigue

Whichever approach is used the activity must be sufficient in terms of time and challenge to demonstrate any differences, though not so that fatigue becomes a variable influencing outcomes. When utilising a within-participants method in which all conditions are tackled by each person taking part, increasing fatigue may play a role in performance. As well as counterbalancing the trial order, protecting participants from this 'carry over' effect by providing sufficient rest between trials and by monitoring their physical state (e.g. by using questioning and heart rate monitoring) may be necessary. The trial order analysis should indicate if fatigue has been a factor in performance outcomes as times will diminish through the trials irrespective of trial order.

3.4.8 Training

Whilst between-groups designs are protected from any training benefit, the repeated measures approach includes the risk that as those taking part undergo more trials, they gain a training benefit which informs and assists subsequent runs. Such development could occur in relation to psychological and technical competence in the activity, more effective interaction with the environment and by becoming more attuned to the equipment. In order to combat this issue the trial order must be counterbalanced so that any training benefit would be apparent in the analysis (because scores would progressively improve through the trials irrespective of the condition). All participants must be given sufficient opportunity to warm-up and practise until such time that they are confident they will make no significant performance gains through the tests. Whilst participants' reporting on their readiness is not guaranteed to be accurate, a pre-test on the experimental course under full protocols can also be deployed as the first trial for each participant to deal with any residual training gains. It is also possible to include activity between each trial to disrupt any mental rehearsal or reflection on the previous attempts in order to reduce a potential training benefit; this is based on working memory's small capacity and short storage duration (Smith *et al*., 2003).

3.5 Measurement and data gathering

A variety of measures are possible ranging from questioning of participants following their performance to ascertain which trial they found most beneficial; observation and expert analysis of participant performance or the use of absolute and objective measures, such as time, which are free from human error. In order to maximise generalisability of any results and to avoid contamination, primary data collection seems best conducted via the most objective means possible. Secondary data, for example gleaning the views of participants, could provide a useful comparison as well as aiding understanding of the focal points used by participants; this may need to be gathered by questioning though some basic physiological measurements may be possible.

With these considerations in mind, a quantitative, experimental approach to data collection seems most appropriate for the gathering of primary data i.e. accurately timing performances using remote mechanical means. This is fundamental to the thesis and will provide the critical information with which to compare the different conditions and establish any statistically significant causal links between trial type and performance. Some secondary data can also be gathered by mechanical means (e.g. heart rate information) and may be analysed in the same inferential manner as performance times. Other secondary data will consist of subjective reporting by the participants in response to questioning or in their provision of self-scores. Due to the subjective nature of these data descriptive statistical analysis will be most appropriate. This will be straightforward for the ordinal data produced by participant self-scores, though verbal feedback and comments from those taking part will first need to be categorised and treated with a basic content analysis. These data may highlight correlations between timed performance and participants' self-scores and comments. The entire thesis will therefore adopt a quantitative approach though the nature of the analysis will vary dependent on the type of data and the objectivity and precision of its collection. Silverman (2012, Chapter 1) explains critical differences between quantitative and qualitative research methods and the manner in which these approaches may be effectively applied.

3.6 Statistical analysis

In the research design employed in this thesis the dependent variable of time means that the primary data being collected is interval data. Due to the absolute and known intervals (without additional coding) a parametric statistical test can be applied (Field and Hole, 2003, p.271). In the envisaged research there are three trial conditions (proximal focus, distal focus and no-focus control) which will each produce descriptive statistics (e.g. mean times, standard deviations and standard error scores). In order to compare these means an analysis of variance (ANOVA) will need to be used as it avoids the family-wise error[16] of running multiple *t* tests. As a within-participants design is to be adopted with a single dependent variable, a one-way repeated measures ANOVA searching for a main effect of conscious attentional focus on performance time will be appropriate. As Field (2009, p.349) explains, ANOVAs identify only whether there is an overall effect of the experimental manipulation by testing the null hypothesis that all group means are the same. To this end it produces an *F* statistic which compares the amount of systematic and non-systematic variance in the data. It does not though, identify specific differences between the trial conditions; for this, pairwise comparisons need to be generated.

In order to control for Type I and II errors (claiming an effect that doesn't exist and not identifying an effect that does exist respectively), *post hoc* tests need to be used to either control for family-wise error or to add statistical power. As

[16] Due to a multiplication of the potential Type I errors (false rejection of the null hypothesis) by the number of independent variables (in this case $1- (.95)^3$) the probability of making a Type I error increases from 5% to 14.3% (Field, 2009, p.348). This is clearly above the criterion of 5% ($p \leq .05$) for statistical significance in social science research.

there are only three variables to be compared in the study design in the current project, Bonferroni's test is the most effective in controlling for Type I errors (Field, 2009, p.372-374), though this does have a potential impact on power (statistical sensitivity). A further issue which may have a detrimental effect on repeated measure ANOVA output is the degree of difference between each pair of scores i.e. between conditions 1-2, 1-3 and 2-3. Field (2009, p.459) explains that this type of ANOVA assumes that the variances of the differences between the variable pairs is similar, this is known as sphericity and it is assessed by using Mauchly's test. If this is violated the *F* statistic may be less accurate so it is important to correct for this by a further modification. Depending by how much sphericity is compromised, as reported with a chi square value (χ^2), different degree of freedom adjustments can be applied: Greenhouse-Geisser and Huynh-Feldt are the most commonly needed. Once these procedures are completed the inter-condition relationship can be produced; a confidence interval of 95% (a probability value (p) of .05 or lower) will indicate a statistically significant difference between performances under the different trial conditions.

A final test which needs to be applied is to calculate the magnitude of any effects. It is common in the literature to quote partial eta squared (η_p^2) though Field (2009, p.386) points out that whilst this provides the effect of the main ANOVA, it actually slightly over-estimates effect sizes. He recommends omega squared (ω^2) as an unbiased measure. As the statistical software to be used (PASW) generates partial eta squared this may be why it is favoured over the latter method – omega squared has to be calculated manually and, as personal experience has demonstrated, it is a complex and time consuming mathematical process. In this work partial eta squared (η_p^2) will be provided to match with current convention and also because it is overly difficult to check the accuracy of the very lengthy omega squared calculation. The caveat that partial eta squared (η_p^2) can slightly overstate the effect size should be borne in mind.

In each of the ensuing research reports descriptive statistics will be followed by inferential ones; these will be obtained using the PASW statistical software package. The *F* statistic result of the main ANOVA will be provided along with the significance value indicating whether or not the $p \leq .05$ criterion is met. The result of Mauchly's test will be reported along with the correction used if sphericity has been violated. The *post hoc* pairwise analysis will be stated along with the adjustment used. This will demonstrate whether there is a statistically significant difference in performance in the three trial conditions in relation to one another. Further ANOVAs can be deployed to check for the impact of the experimental conditions on other measured output e.g. peak heart rate, and also to ensure critical variables are effectively controlled. Where ANOVAs are not used, descriptive statistics may be reported to highlight interactions. The secondary data collection, i.e. the verbal information from the participants, will be subjected to a basic content analysis. Comments will then be categorised and summed so that descriptive statistics may be produced.

3.7 Results

In all cases, the results will be presented in standard tabular and graphical form with explanations as required.

3.8 Discussion

The results from each experiment will need to be discussed in relation to the present research position as described in the literature review (Chapter 2).

3.9 Ethical considerations

When dealing with human participants, especially when running experiments in potentially injurious sports environments, it is critical to ensure that all necessary protection is in place and participants volunteer in full knowledge of what they are being required to do. With this in mind, activities and environments need to be chosen in which the participants can be supported, assisted and rescued at any point. Informed consent will always be gained in writing once the participants have read a written briefing detailing the activities they will be engaged in and what they will be asked to do. Medical and emergency contact details will need to be provided by all participants. All volunteers must be made aware that they can cease their participation at any point and will be under no obligation to continue to the end. I hold the UK's highest national qualifications for the activities used and am competent to make appropriate decisions and to provide all necessary support. These qualifications are also valid in the United States. Appropriate insurances will need to be obtained for research work both in the United Kingdom and the

United States. All experimental protocols will need to meet the University of Edinburgh's research ethics requirements and to be approved by the university before use.

3.10 Developing the methodology

3.10.1 Prior study

Previous work (Banks, 2009), conducted as part of an earlier Masters degree (which was also funded by the Economic and Social Research Council), demonstrated the logistical difficulties of running a study in an open skill environment. This study used a between-group design comparing initial skill acquisition as well as later retention and transfer. Groups were small and individuals were quasi-randomly assigned following pre-tests and rank ordering. Sea kayaking a fixed, linear course in small, consistent waves was used to compare a proximal and distal focus. No control group was used and attentional focus was not subdivided into visual and conscious. An evaluation of skill was made by expert markers who were unaware of the purpose or conditions applied to the participants. The requirement for regular, consistent environmental variability proved crucial in producing fair and meaningful comparisons between individuals and factors as well as over time for retention and transfer tests. Whilst this small study was manageable, proper academic rigour was challenging to maintain. This was exacerbated by the choice of measure and the method of measurement.

3.10.2 Activity choice and context

On the basis of this valuable experience, and notwithstanding the above challenges, initially, my favoured option for the present thesis was to again try to find an activity and environment which would permit attentional focus effects to be evaluated in a continuous open skill as, to my knowledge, this has not been researched before. Sea kayaking again seemed to provide a suitable activity, though design modifications would need to be implemented to improve the rigour of the study. Requiring competent kayakers to paddle a fixed, linear course perpendicular to incoming waves under three conditions (an external proximal focus, an external distal focus and a control condition without a focus provided) still seemed to enable an evaluation of attentional focus effects. Rather than judging performance using expert markers as previously, accurately measuring the time taken would produce interval level data which could be analysed using parametric statistics. To ensure accuracy, measuring performance on a calibrated course under each condition could be recorded using a High Definition video camera with a high frame rate[17], this would make it possible to advance the footage one frame at a time to establish time taken. This method also maintains a record so that measurements and procedures can be verified later.

The initial desire to assess retention and transfer (two of the three normal, skill acquisition measures) meant that a between-groups approach would be

[17] High Definition video can run at 50 frames per second which equates to .02 seconds per frame. This should be more than sufficient to accurately establish differences in performance time and to remove measurement error.

required. Each participant would have to return at fixed intervals on at least four separate occasions for pre-testing plus a minimum of two acquisition trials as well as retention and transfer tests. Considering that the participating individuals were likely to have a wide variety of personal circumstances and in some cases to be travelling significant distances to take part (as opposed to being a relatively 'captive' group such as undergraduate students) this was a logistically challenging proposition. It was made more so when the lack of practical assistance was taken into account; only one person being available to help.

Bearing these issues in mind, and following discussions with Gabriele Wulf following her invitation to meet her at the University of Nevada, a within-participants design replaced the between-groups approach as this was clearly impractical. This meant that it was not possible to assess retention and transfer; only immediate performance would be measurable. This decision immediately reduced the number of participants required and made the logistical demands more manageable with the resources available. Having decided on this methodological approach the specific environment and experimental parameters needed to be established.

3.10.3 Location selection

Following the encouraging Masters degree study conducted on the sea at Walney Island, Cumbria, UK (Banks, 2009), a similar though more consistent sea shore site was sought for the present project's research. Due to a lack of such conditions in the British Isles, and in light of having a number of paddle-sports contacts in San Diego, California, where stable weather could potentially provide the regular conditions required, this was chosen as the venue. Several possible beach sites were examined in San Diego and, initially, the small tidal range[18] coupled to regular climatic conditions appeared to offer hope that a high quality study may be possible. Having committed to this, the sites examined included Mission Beach, Dog Beach and Coronado Beach though eventually the beach at La Jolla was selected for the study as it provided the greatest ease of access, the fewest other water users and the most consistent environment.

3.10.4 Participant recruitment

Using the connections previously established in Southern California, a list of potential individuals, organisations and establishments were compiled and contacted with a view to participation in the studies. Many of these did not respond (e.g. University of California). Several meetings and discussions were held with others though were ultimately unsuccessful for a variety of reasons, for example San Diego State University (the Sports Science Department - was very keen to participate though it was eventually overruled by the Research Ethics Department), Southwestern College (offers of help and support did not materialise despite a very positive meeting with the Director of Sports Studies) and the United States Navy's rehabilitation programme (it transpired that the former sailors and marines involved were not all psychologically stable enough

[18] Tidal data on the mixed semi-diurnal tides which affect San Diego can be found on the United States Harbors website http://ca.usharbors.com/monthly-tides/California-South%20Coast/San%20Diego

to participate in such studies). Others were happy to assist within certain limitations (e.g. San Diego Canoe and Kayak Team (SDCKT)) as long as it did not disrupt their normal operation and training.

Whilst many weeks were taken up pursuing the various possibilities, ultimately, the greatest success came through accessing the San Diego Sea Kayakers group – an informal association of individuals who occasionally paddle together and agree various venues for their activity - and the Blue Herons kayaking club. Through these networks of active paddlers it was possible to communicate with a large number of people in person and to have them contact each other with a view to increasing the pool of potential participants. This generated over twenty individual participants for the proposed research.

3.10.5 Refining the experimental design

Trialling this outline design in an open skill environment soon demonstrated significant problems. Firstly, whilst the venue selected (La Jolla, California) was a reasonably quiet environment, the presence of other water users interfered with the experiment despite trying a variety of times of day. The second major issue was that whilst reasonably regular on the Pacific coast, waves do (and did) arrive in sets and therefore provided a range of challenge preventing accurate comparisons between participants; the waves also tended to slightly move the buoys used to mark the course so an accurate distance was difficult to maintain. Competence level was a further important factor in that the varied conditions excluded several potential participants and reduced the overall number of people who could provide sound data. Given the difficulties of recruiting participants in the first place this was certainly not helpful. After several attempts to run tests under full experimental protocols this idea was abandoned. Despite this time consuming setback many benefits had been gained: protocols had been established which would be transferable to later work, equipment had been tested and relationships developed with many organisations and individuals as well as potential participants which encouraged them to volunteer for future studies.

Following this abortive attempt and upon reflection, the difficult decision to run an attentional focus study using a more closed skill in a placid venue was taken. Whilst the intention to use kayaking remained, this change meant that a completely different type of environment would be required which was relatively free from environmental complexity and uncontrollable variation. This did have the consequence that the desire to examine attentional focus in open skill performance would have to be postponed. Extensive visits identified several potential venues (e.g. Chula Vista Marina, Southwestern College boating base, Lake Murray and Tecolote Shores) though a very quiet lane of clear water at the extremities of the Quevira Basin Marina in San Diego seemed to offer the best blend of access, consistent conditions, lack of disturbance, ease of course setting and measurement as well as being protected from any wind.

The next regime considered was to use a more challenging type of boat in a closed skill environment whilst retaining sufficient task difficulty to amplify any trial effects. With this in mind the sea kayak was replaced by an open cockpit racing kayak (surf ski), a craft widely used in Southern California. This would still comprise an extension to previous work in that it would compare different external focus distances in a continuous skill. Further successful pilot work demonstrated the appropriateness and viability of both craft and water conditions for the intended research. The use of a within-participants design to compare timed performance in a closed continuous skill under different attentional focus conditions therefore became Study 1. This placid water, surf ski sprinting study is described in full in Chapter 4.

3.11 Summary

Clarifying the available methodological approaches and their implications for the proposed research in this thesis led to a preliminary study structure which was refined and developed over time. The initial desire to examine conscious attentional focus in an open skill proved overly ambitious for a first step. This will now be worked towards in a more systematic fashion. Whilst the journey to this point was a protracted process, it has led via consideration, discussion and the exploration of practical possibilities, to a more appropriate methodological approach and an experiment which is manageable given the resources available.

Chapter 4

Study 1

4.1 Introduction

The initial attempt to run an applied, open skill study into external, attentional focus effects using sea kayaking in San Diego, California, proved to be unworkable as previously explained (Chapter 3). This experience led to a reconsideration of possibilities in Southern California where a stable climate and available volunteers could be used to best effect. San Diego is subject to a small temperature range, low average wind speed and very little precipitation[19], this leads to predictable and consistent conditions; it is ideal for canoe-sports and there is a significant paddling population. A plan was therefore developed to run a study in an applied, closed skill environment using a within-participants design. This was to reduce the logistical challenges and the numbers of participants required: in effect, it would make the study viable with the resources available.

With this in mind surf skis were identified as a potential 'vehicle' for such an experiment: the notion being to compare the performance of individual paddlers in speed trials in a variety of attentional focus conditions. Surf skis are designed to travel fast in a straight line; the repetition of an effective forward paddling technique is important to generate maximum speed. In a benign

[19] Average temperatures for June and July are 19.3°C and 21.7°C respectively; wind speeds for the same months average 7.8mph and 7.5mph whilst precipitation for June is 0.25cm with an average of 0cm in July. The following link provides comprehensive meteorological information on San Diego http://www.climate-zone.com/climate/united-states/california/san-diego/index_centigrade.htm

environment without external distractions or variables this constitutes a relatively closed skill. Appendix 1.1 has images and a description of the craft (Figure 1a, 1b and 1c).

As the case for an external focus benefit relative to an internal focus has already been well made and is demonstrably robust (Wulf 2007a, 2007b), it seemed that an attempt to use both an applied and naturalistic task and to examine different external focus points would be informative. This was reinforced by an earlier, small project using sea kayaking (Banks, 2009) which identified a potential benefit of a distal as opposed to a proximal focus (focusing out to sea rather than on the boat).

4.2 Pilot study

As paddling a surf ski was an entirely new discipline to me and an appropriate venue or test had not been identified, several pilots needed to be run and potential venues examined before the study could be started.

Once a high quality surf ski in excellent condition had been acquired on a long term loan, trialling the boat showed it to be a very fast and somewhat unstable craft. Whilst it may have proven overly testing for novices to kayaking in general, given the time constraints of the study, it seemed likely that competent or experienced kayakers would be able to adapt to the boat in the time available. Using a benign environment without variation or distraction seemed likely to further facilitate such familiarisation. The decision not to recruit novices to this study should not be taken to mean that unstable craft are unsuitable for beginners, rather the time and effort which was likely to be required for them to reach a performance plateau, where there would be no discernible training benefit across the trials, may have been quite long. The use of more competent paddlers was a judgement based on my personal experience of coaching and teaching multiple forms of canoe-sport at all levels from beginner to expert in a wide range of environments for more than twenty years.

Identifying an appropriate distance and set of protocols were the next challenges. Initially a 50 metre distance was thought to be sufficient to highlight any differences between trial conditions without causing a detrimental fatigue effect. Using experienced kayakers as volunteers at Telecote Shores in Mission Bay, San Diego a series of pilot tests was conducted which demonstrated that such a distance was covered very quickly and may be too short. In addition, it became obvious that a poor start would have a disproportionate impact over shorter courses and therefore a method of removing reaction time from the overall time was necessary. Doubling the run distance to 100m was apparently suitable for fit and athletic individuals though fatigue seemed likely to impact on those less fit or unfamiliar with such a boat - due to the fact that sprinting in them requires high levels of energy and effort to be expended. Less experienced individuals may also use additional effort in tasks such as stabilisation which might undermine their forward paddling effort sooner. In the context of this study unfamiliarity is defined as having no, or only very limited, experience in a surf ski. On the basis of this experience a run of 75 metres was decided upon as the test distance. In the absence of any straightforward mechanism to assess individual fitness for the tests, having a course length that would be suitable for a range of participants seemed the most appropriate. Timing participants from the moment their first paddle stroke entered the water would also ensure that only movement time was measured thus overcoming a poor reaction to the start.

4.3 Experimental design

4.3.1 Participants

Twenty one experienced, competent and currently active kayakers from a variety of paddle sport disciplines volunteered to take part in the trials. The age range was 19 to 70 years with a mean age of 55.4 years. Ten of the participants were female. Ten had experience of paddling surf skis. All the volunteers were United States citizens and all were white Caucasians – in the United States and the United Kingdom it is uncommon to encounter canoeists from any other ethnic background. One participant did not complete the trials due to a capsize on one run; therefore there are only twenty complete data sets. (This participant did go through the whole process however so that they felt that they had contributed fully to the study. They were thanked for their time and effort though not informed that their data would not be usable).

4.3.2 Ethics

Before commencing any experiments insurance had been acquired to provide cover for personal accident, third party injury and damage as well as for professional indemnity in the United States. The British Canoe Union had agreed to permit coaching and research in paddle sports to take place under their policy whilst in the United States. Following consultation with adventure sports providers and coaches in the United States a lengthy waiver document was produced which had to be read, completed and signed by all participants (Appendix 1.2). This document also required the participants to list any issues (injuries, ailments, allergies, medication etc.) which may have affected their involvement or which may have needed to be passed to medical personnel in the event of their becoming incapacitated.

All participants, on arrival at the venue, were also given a written briefing on the testing procedure and made fully aware that they should only take part if happy to do so. They were informed that they were under no pressure to continue if they felt uncomfortable at any point and could withdraw at any time. The full Participant Briefing can be found in Appendix 1.3. Participants were reassured that they would remain anonymous i.e. they would not be named or otherwise identified and it would not be possible to trace any published data or results back to their performance. Their permission was sought to record their performance on video, on paper and via a heart rate monitor.

4.3.3 Equipment

An 'Epic V10' surf ski (Figure 2a), suitable for paddlers of different heights and weights with adjustment for leg length via variable pedal positioning, was used for all trials. An 'Epic, Greg Barton, Signature Series', wing paddle[20] adjustable for length, feather and handedness[21] was purchased and used for all participants. This is a mid-sized, full carbon paddle weighing approximately 700g.

Due to the temperate weather (between 24°C and 27°C during daytime) and warm, shallow water (between 2.5m and 3.5m in the centre of the test venue depending on the tide) only lightweight clothing was required. All participants used their own paddling attire and footwear and no-one was permitted to change their equipment or clothing part way through the testing. All participants were required to wear a buoyancy aid for personal floatation should they fall in; whilst one was provided, participants were permitted to use their own if this provided a better fit and did not hamper their paddling action. As with clothing, once a selection had been made no changes were allowed part way through the trials.

Experimental equipment comprised a Panasonic HDC TM 900 High Definition Video Camera with 16 gigabytes of built-in memory and a further 16 gigabytes

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[20] Wing paddles are so called because the blades are shaped like an aeroplane wing or a boat's sail. Compared to a non-winged blade which provides an anchor point in the water against which the paddler can pull to move the boat forward, wings also provide lift on the rear, convex surface as a result of a relatively low pressure area created as the paddle moves back and away from the boat during the forward paddling action. They were first used by the Swedish national kayak sprint team in the 1980s and conferred a 2% benefit to performance times. Wings are now the norm for flat water sprinting and are becoming popular in other disciplines too.

[21] Adjustable length allows the paddle to be sized correctly for the user. Feather is the difference in relative angle between the blades. This usually varies between 0° and 90°. In this experiment it was fixed at 45°. When using a 'feathered' paddle one hand constantly grips the shaft whilst it rotates in the other hand. This controls the blades so they enter the water appropriately. The control hand can be selected for either left or right handed paddlers.

of memory provided via a secure digital (SD) memory card. This was mounted on a Sherpa PH157Q tripod to provide critical stability. A Polar FT1 heart rate monitor, comprising a transmitter attached via a chest strap and a data recorder in wristwatch form, was used in all trials. The data recorder was mounted on the shoulder strap of the buoyancy aid so as to be out of sight of the participants and to make it easily accessible to the researcher.

A general purpose kayak, kayak paddle and buoyancy aid was borrowed and positioned on the bank so that assistance could be provided to anyone requiring it in deep water. This craft also served as a support boat, for those who wished it, during the familiarisation period before testing. This equipment remained consistent for all trials. A 75 metre length of twine was used to measure the course; this was done once from the inward end of the study location along the bank to a fixed and obvious point where the camera and transit could be positioned. This point was then used to site the finish in all subsequent trials. The start was marked by a padded fabric sheet against which the stern of the boat was placed at the start of each run (Appendix 1.1, Figure 1b). The finish (which was not visible to the participants) was provided by a transit across the course using a red can and a fixed post in line with the camera. No physical finish line was apparent to the paddlers. Participant information sheets were present so that they could be read out in advance to all those taking part. A clipboard and individual data sheets were produced to record information during and after the trials (Appendix 1.5). A first aid kit was always available.

4.3.4 Venue

A 200m stretch of very placid water in Quevira Basin, Mission Bay, San Diego, California was used for all trials in June and July 2011. This was in a part of the basin housing the marina jetties and furthest from any other potential users and disturbance. It was sheltered from any wind or waves by a breakwater to the west side. The venue was approximately 15 metres wide and bounded on its east side by a jetty with moored yachts. There were no other water users, passing traffic or visual distractions (Appendix 1.1, Figure 1b, 1c and 1d).

4.3.5 Environmental hazards

Quevira Basin has a marina, boat repair yard, kayak centre and a variety of access points for water users. Whilst the extremely sheltered venue used for the testing was unlikely to be disturbed, during the familiarisation period before testing, the open water of the basin was often used and any other water users could have provided a hazard. When participants decided to warm up and practise in the surf ski in this area they were always supported by the researcher in the general purpose kayak. All the water used was sufficiently deep for paddling, and so that a swimmer could not touch the bottom, almost immediately from the bank; the bank itself was rocky and slippery. The depth was such that there was no chance of any drag being caused to the surf ski whilst in use.

Round Sting Rays (*Urobatis halleri)* were present in the water and are responsible for inflicting very painful stings on many water users every year –

particularly during the mating season which is April to June in Southern California. Due to the depth of the water in the area of the experiment and the low risk of anyone capsizing and being able to walk on the bottom they were deemed unlikely to be a serious threat. Californian Sea lions (*Zalophus californianus*) frequent Quevira Basin in significant numbers and bask on many of the jetties. These pinnipeds are large, powerful animals which could easily capsize a kayaker and inflict a damaging bite if provoked. They were not present at any time on the jetty or breakwater bounding the testing area and were given a wide berth when practicing in other parts of the basin. All those taking part were briefed on issues such as seal lions, rays and slippery and loose rocks and advised to be mindful of other water users in the open basin area. The support kayak was used to provide safety cover when necessary and to reduce the potential anxiety participants might experience in a boat which they may be unfamiliar with.

4.3.6 Staff

In addition to being responsible for the organisation, set up and safety of the study I also briefed all the participants as well as starting and hand-timing each performance. Hand-timing was conducted using a stopwatch as a backup to the video camera. Data from the heart rate monitor were recorded after each trial as well as participants' self-scores and their comments on their performance and experience. A professional photographer operated the video camera.

4.4 Control of variables

Given the naturalistic format of the study there was the potential for a range of variables to confound the results, these were assessed and controlled as follows:

4.4.1 Trial order

The distal, proximal and control conditions were counterbalanced and rotated through all six (3x2x1) of the possible combinations. These were listed in advance and the next participant to present themselves was placed in the next combination so that pre-ordering could not inadvertently select certain individuals for certain trial orders. Appendix 1.4 shows the trial order for each kayaker).

4.4.2 Vision

As this experiment was an assessment of conscious focus, visual focus had to be controlled. This was done by requiring the participants to look at the same fixed point in front of them, well beyond the actual finish, during all three conditions. The participants were all asked after each run to estimate what percentage of the run's time they had looked at the point specified. This created a check to ensure that they had indeed maintained a visual focus as required.

4.4.3 Modelling

In order to prevent any modelling, participants were carefully timetabled so that they would not inadvertently be able to observe one another. They were told to not arrive early for their trial and were only given the venue location the day before their test to avoid any possibility that they might come and watch others or practise *in situ*. Only one volunteer was ever present at any one time.

4.4.4 Practise

As part of the communications sent out to prospective participants they were informed that they would be paddling in a surf ski. The decision was taken to inform them as it may increase the appeal of the study. The prospect of those taking part going out to practise was considered, though this was deemed a low risk and, due to the repeated measures design and their lack of knowledge of the study, was unlikely to have any impact even if they did.

4.4.5 Fatigue

As paddling a surf ski and sprinting may have been activities which the participants did not take part in, there was a risk of accumulated fatigue during the trials affecting their performance. This could have been exacerbated by any anxiety they felt in an unfamiliar boat – particularly if it was less stable then their usual craft – though it was not possible to measure anxiety or its effects. In addition to the activity familiarisation period (above) a heart rate monitor was fitted to each participant so that their starting heart rate could be monitored and allowed to recover fully between runs. Peak heart rates were also recorded so that maximal effort was monitored: if this dropped consistently from the first to last run it may have indicated that the participant was tiring. This is, of course, an imprecise guide as other factors such as trial conditions, motivation, effort, anxiety etc. may also impact on peak heart rate.

4.4.6 Training effect

The trial order counterbalancing had the additional benefit of allowing the identification of any training benefit from the first to the third run. However, due to the varied prior experience of the participants and the fact that only ten of them were surf ski paddlers and/or racers, there was a possibility of a training effect as they progressed through the trials. To combat this each participant was briefed that they must warm-up and familiarise themself with the craft for sufficient time so that they felt that they had plateaued in terms of short-term improvement. They were asked to practise sprinting though not to use so much time and energy that they became fatigued. Both training and fatigue effects were explained to them and why they needed to be avoided. This meant that differing amounts of time was utilised by participants before their testing phase began. Whilst they were often provided with safety support during this period they were never permitted any coaching or guidance as this may have been something they later considered or focused on during the tests. In addition to the above preparation, each participant had a pre-test as an additional run in advance of the experimental trials; this served several purposes. In regard to any potential training benefit it acted as a 'dress rehearsal' and real-time practise for subsequent runs thereby tackling any residual anxiety and sudden performance gains. The pre-test is explained more fully later.

4.4.7 Trial briefings

In order to be memorable and usable, briefings needed to be concise and succinct. The difficulty lies in choosing either to provide identical information delivered in the same manner for everyone – thus risking a level of misunderstanding or interpretation – or to provide sufficient information for each participant to ensure that each has complete understanding and cannot misinterpret the instructions. In this experiment the decision was taken to read out set instructions for each trial but then check that each individual was absolutely clear on the task they were being asked to perform. The instructions for each trial condition can be found in Appendix 1.6.

4.4.8 Expectations

In a study such as this it appeared reasonable to assume that a variety of effects might affect participant effort and performance as they strove to demonstrate their competence or, subconsciously, to assist the researcher e.g. HALO, Hawthorne and Pygmalion (Rasmussen, 2008; Rosenthal and Jacobson, 1968). It was therefore crucial to prevent any knowledge of the purpose of the trials becoming known. As well as providing no information as to the purpose of the experiment to participants, the use of the heart rate monitor was overt and acted to encourage the belief that the testing was physiologically based – at the very least it provided a distraction away from the notion of focus effects. Participants were also asked for a self-score and verbal feedback after every trial to see if their expectations of which conditions would be fastest influenced their effort. This would also provide information on participants' perceptions of their performance in relation to measured speed on the different runs. Whilst self-evaluation was not the primary data source in this study it is a commonly employed method of cross-checking that participants have followed instructions and is a useful means of comparing perceived performance against that measured e.g. Freudenheim *et al.* (2010).

4.4.9 Environmental conditions

Environmental conditions remained stable across all trials in terms of weather, temperature and water conditions. Mixed semi-diurnal tidal fluctuations are 1.5 metres on springs and no current was present at any time[22]. As participants' trials took approximately 30 minutes to complete in total, the maximum depth change based on the Rule of Twelfths[23] would be 0.19 metres in the third and fourth hour of a spring tide (((1.5÷12) x 3) ÷ 2). The venue previously described thus provided a calm, sheltered, stable and undisturbed testing location.

4.4.10 Information sharing

All the participants were thoroughly briefed on the necessity to not discuss their experience with anyone else as this might influence the performance of others taking part in the trials and thereby compromise the results.

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[22] Tidal data on the mixed semi-diurnal tides which affect San Diego can be found on the United States Harbors website http://ca.usharbors.com/monthly-tides/California-South%20Coast/San%20Diego

[23] The Rule of Twelfths is a simplified method of calculating tidal height at any given point during a tidal cycle where there are no tidal anomalies. The Royal Yachting Association provides a succinct explanation on their website: http://www.rya.org.uk/cruising/navigation/Pages/tip.aspx

4.5 Method

A within-participants design was selected to assess the relative impact of a distal, proximal and no-focus control condition on surf ski paddlers. This removed the need for complex timetabling and large numbers of volunteers to take part. Matched groups would therefore not be required and *post hoc* retention and transfer testing would not be possible (as the participants would be exposed to all factors and therefore could not be compared later).

On meeting each paddler and following introductions, the waiver form was read, completed and signed by each volunteer; the briefing was provided to them to read. It was emphasised to each person that the choice to participate was theirs alone, they were under no pressure to take part or to complete the tests and that they could withdraw at any time and for any reason. Once suitably attired the participants were shown the boat and equipment and helped to fit and adjust everything to their personal preference. This was done on a flat, grassy area rather than on the water. When ready, the participant was invited to follow any land based warm-up routine they wished and they were then supported into the boat. They were encouraged to warm-up in the boat to reach a level of comfort and familiarity so that they felt they would not make significant performance gains as a result of the testing regime. They were also asked to practise sprinting, again in order to reduce potential training effects during the trials, though to ensure that they did not exert themselves to the point where they would not be able to sprint to their full potential in all four runs. This period varied significantly across participants depending on prior experience and confidence in a surf ski. The range was approximately 10 to 30 minutes. The speed trials comprised four separate sprints of 75 metres. The distance was chosen (following a pilot study) so as to be long enough to highlight any differences but to avoid any fatigue effects.

Whilst all those taking part were experienced paddlers only half had any experience in surf skis. It was therefore necessary to judge when each individual participant had familiarised themselves sufficiently with the boat so a training effect through the tests could be avoided. There was no straightforward way to measure this, therefore when a participant indicated their readiness they were asked if they felt they would not make significant further performance gains by virtue of having the four consecutive sprints. Their subjective view had to be matched by my analysis of their progress; if the two did not concur then further familiarisation time was prescribed until agreement on readiness was reached. Once this had been achieved the participant proceeded to the start which was marked by a padded rock at the south end of the course against which the stern was positioned. All participants were shown the line which they were to sprint down as well as the area (beyond the actual finish) where they could stop paddling; they were informed they must sprint as fast as possible in all runs. They were not shown the actual end point; no physical finish line was present or visible. Figure 4a (p.188) provides a schematic representation of the Quevira Basin venue and experimental organisation. Appendix 1.1 provides images of the venue in use.

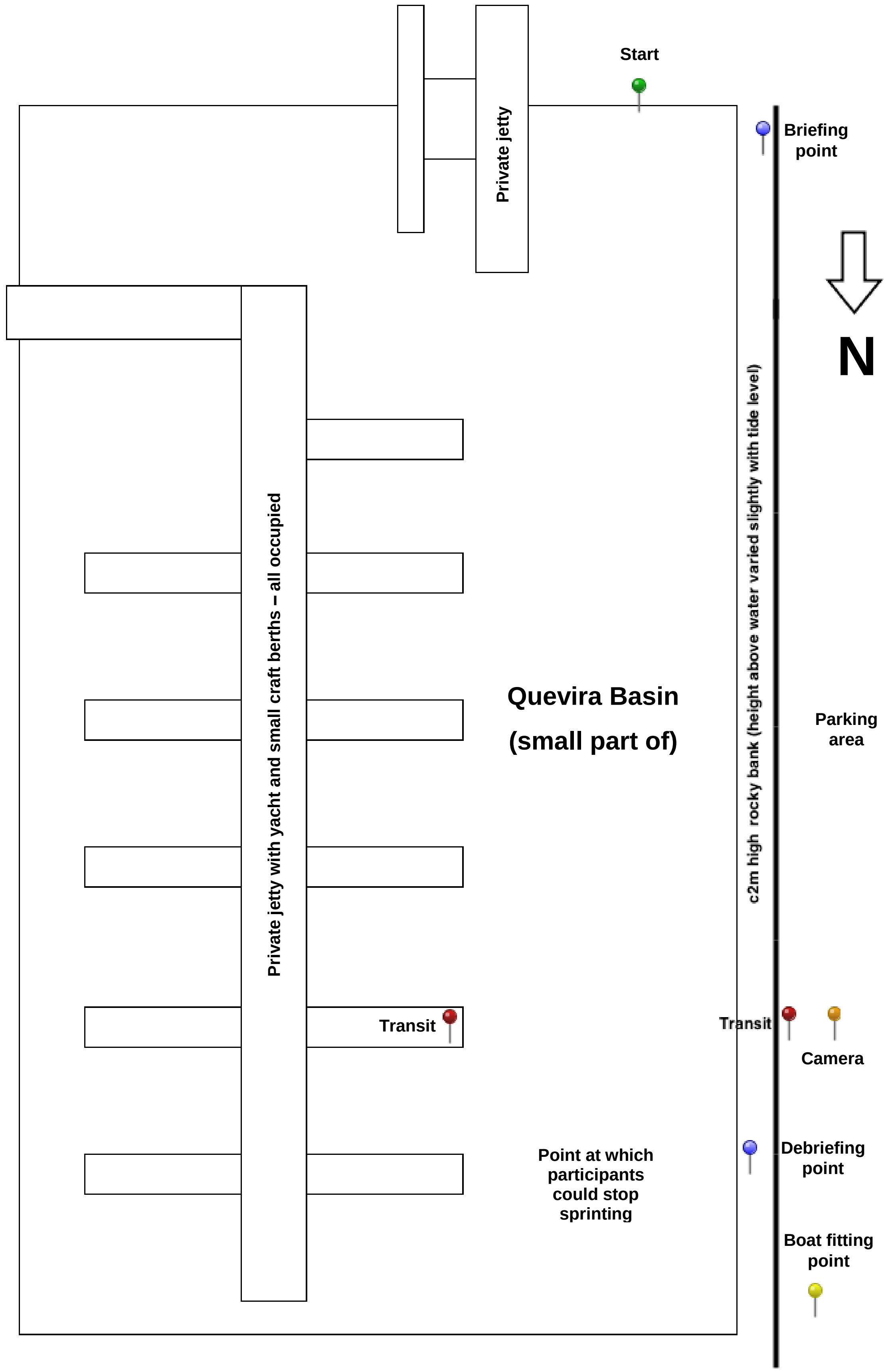

Figure 4a Schematic diagram showing venue layout and organisation

The pre-test was run first for all participants. Once at the start the instructions were read to them and their understanding was checked. They were required to paddle as fast as possible down the identified course. No visual or conscious focus was provided. This therefore constituted a completely normal surf ski racing or training task as the paddlers had the freedom to focus on and look at whatever they chose. For all experimental trials (control, proximal and distal) the paddlers were shown a fixed point well beyond the finish in front of them and informed that they must look at that point for the duration of their run; this was to control for visual attention. This was emphasised strongly and they were told that they would be asked after each trial whether they had done this.

In the **control** condition no information other than the visual point was provided. Participants were asked to "*Look at the point identified*". Whilst it was not stated, they were free to consciously consider anything they chose on this run. In the **proximal** condition participants were asked and required to concentrate all their conscious thoughts and mental effort on the boat's stability and to not allow anything else to enter their mind (whilst maintaining a visual focus on the fixed point as previously explained). Again, it was explained that this would be checked afterwards and that it was imperative that they make every effort to follow the instruction. The control of boat pitching fore to aft ('bobbing') is often focused on by coaches in race training (e.g. Campbell, 2006); the control of yawing (direction) and roll also need to be attended to in order to sprint effectively. This instruction was condensed and emphasised as "*Think about the boat as requested*". As in the control trial the paddlers were also asked to "*Look at the point identified*" to separate visual attention from conscious attention. The instructions were reduced so as to minimise and equalise the information which had to be absorbed and deployed.

In the **distal** condition, as well as the visual point being separated and controlled as previously, participants had to focus all their conscious thoughts on the finish (i.e. being at the finish, finishing). No actual finish line was identified to those taking part nor was one visible to them (to avoid a visual distraction and conflict). The same, strong emphasis was applied in each case that the required conscious focus and visual reference should be maintained and that the paddler should sprint as quickly as possible. In this trial the two instructions constituted, "*Think about the finish as requested*" and "*Look at the point identified*".

Once the instructions were read and fully understood - and it was clear that they would be adhered to, the participant was given a 3-2-1 countdown to start. They sprinted as fast as they could until told to stop i.e. when they had passed the finish line transit used for timing (see Figure 4a). After each run participants paddled gently to a point against the bank beyond the finish. Measurements and comments were recorded. Following this data gathering, the heart rate monitor was reset and the heart rate checked to ensure it had recovered to its pre-run level; the participant would then paddle slowly back down the course for the next trial. Following each individual's session they were thanked for their time and reminded to not discuss their experience or the trials with anyone until they were all complete.

4.5.1 Measurement and recording

On completion of each sprint participants were held in a stable position by the bank beyond the finish. At no point were they allowed to exit the surf ski once the testing began therefore all instructions and data gathering were provided and obtained whilst in the boat. Participants were asked if they had focused as per the instructions and looked at the visual point as required. Answers were recorded as a percentage of time on task. Each paddler was next asked to provide a self-score between 0 and 100 as an assessment of their performance (speed) on each run. On the first occasion (after the pre-test) it was explained that the figure given could then form a benchmark for future scores. They were also questioned on how they felt each run had gone in a performance sense and what they thought of the condition applied. Their comments were recorded on the individual data sheet (Appendix 1.5). In order to avoid guiding responses or prejudicing subsequent runs every care was taken not to ask questions which were leading or suggestive. The gathering of comments took several minutes and also acted to permit recovery between trials. The basis for using self-scores as a means of gathering qualitative data to evaluate participant perception, and to check that conditions have been adhered to, is well established and commonly used in this field (e.g. Wulf *et al*., 2001; Marchant *et al*., 2007; Stoate and Wulf, 2011).

The heart rate monitor was checked and the peak heart rate recorded before the device was reset. Participants' heart rates were checked to ensure they had returned to their starting level before the next trial was commenced. Once it was clear their heart rate had recovered they would then paddle gently back to the start and reposition themselves for the next run thus further adding to the recovery time. On no occasion was further recuperation time required beyond the run debrief. Each sprint was videoed for later analysis and to harvest the times. The participants were also hand-timed as a back-up to the camera. Whilst the camera had a maximum frame rate of 50 per second in full High Definition mode it was deemed accurate enough to use Advanced Video Coding High Definition mode (AVCHD). This runs at 25 frames per second or 0.04 seconds per frame. This mode also had the additional advantage of allowing smoother playback on non-High Definition computer screens.

The time taken by each participant on each run was from the point at which their paddle first entered the water to the point at which their bow passed the finish line transit. By advancing or rewinding the video by one frame at a time an extremely accurate time could be recorded for each run; this method also served to remove the impact of a slow or variable response to the start instruction or, indeed, of anyone pre-empting the instruction. At the completion of all sprints, and after the final data set was complete, the participants were asked to place the four conditions in an order of preference and to explain their reasons. These were recorded on the standardised data sheet.

4.6 Results and analysis

Primary data were collected to examine the impact of conscious attentional focus (independent variable) on time (dependent variable). The experimental data and its analysis form the evidential basis for any claims of causal links. Due to the fact that the experimental method used a within-participants design seeking a main effect of attentional focus on performance time (in three conditions), and the scores collected provided interval data, parametric statistical analysis is appropriate. A one-way, repeated measures analysis of variance (ANOVA) was therefore the most suitable statistical method to use (Field and Hole, 2003, p.258-284). Employing this particular ANOVA also requires further procedures to be conducted including Mauchly's test for sphericity, and the application of any corrections required, as well as pairwise comparisons of the three conditions to identify any inter-trial differences (having corrected to protect against Type I errors). In the case of statistically significant differences, a measure of the effect size is also provided (partial eta squared). Potentially confounding variables (i.e. trial order, fatigue effect and training effect) were also controlled therefore the analysis needs to check that this was done effectively; descriptive statistics and ANOVAs have again been used in this regard. Chapter 3, section 3.6 provides a more thorough explanation and justification of the statistical processes considered and deployed.

Additional analysis has been conducted on identifiable sub-groups within the data set (e.g. experience and gender) though claims of causal links are not possible due to the danger of gaining false positive and negative results as a function of repeated analysis of sections of the main data set. Furthermore, the theoretical basis for the study did not assess the impacts on all the possible sub-groups in sufficient depth and did not control for other potentially influential factors within those sub-groups. Participants in sub-groups were not recruited with such a specific study in mind. It is also important to note that no additional hypothetical positions were presented beforehand. Therefore, whilst it will be interesting to examine any viable sub-sets of the data, its interpretation may only lead to questions which could be examined via future experiments. Brookes *et al*., (2004), explain the issues associated with sub-group analysis.

Secondary data was also collected in the form of participant feedback and performance self-scores. This data can be analysed and interpreted using descriptive statistics and basic content analysis to examine whether experimental evidence matches individual beliefs, preferences and scores.

4.6.1 Descriptive statistics

Participants' performance speed was measured to an accuracy of 0.04 seconds under the three experimental conditions. Figure 4b provides a visual representation of the relative means. Note that the y-axis origin does not begin at zero; this is to facilitate clearer comparisons.

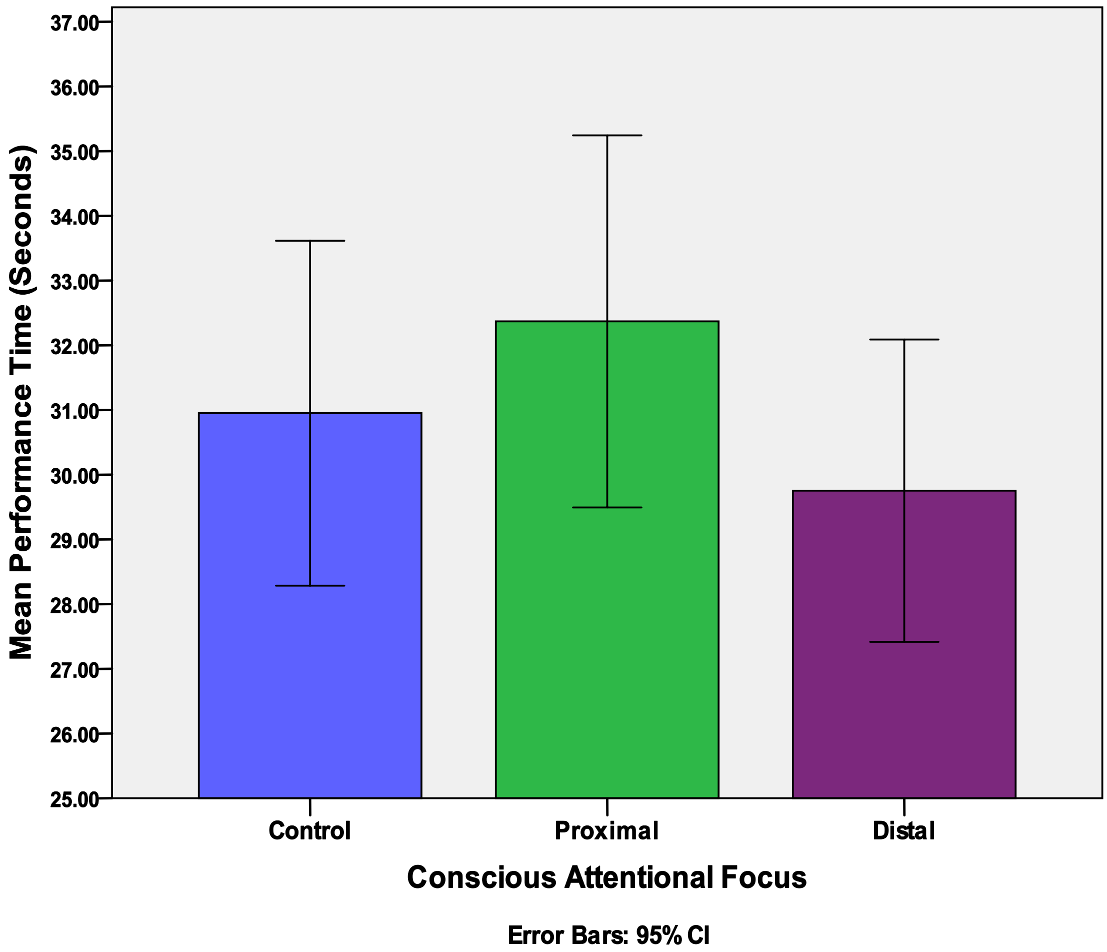

Figure 4b Performance time related to conscious attentional focus

Table 4.1 Standard deviation and standard error values

Condition (focus)	Mean (seconds)	Std. deviation	Std. Error	Number
Control (no focus)	30.95	5.69	1.27	20
Proximal	32.37	6.14	1.38	20
Distal	29.75	4.99	1.12	20

Figure 4b and Table 4.1 show that participants performed more quickly under the distal focus condition than in either the control or proximal trials. The proximal condition appears to have produced the slowest performances.

Individual performance times varied markedly across the group though the range was smallest in the distal condition and greatest in the proximal.

4.6.2 Inferential statistics

Mauchly's test indicated that the assumption of sphericity had been violated, $\chi^2(2) = 7.98$, $p < .05$, therefore degrees of freedom were corrected using Greenhouse-Geisser estimates of sphericity ($\varepsilon = .74$).

The results show that conscious attentional focus had a significant effect on the speed of kayaking performance, $F\,(1.47, 28.0) = 23.30$, $p < .001$, $\eta_p^2 = .551$

The overall effect size reported above ($\eta_p^2 = .551$) represents a strong effect; as Harris (2008) points out, an effect size greater than 0.14 is considered large. The effect above accounts for more than 55% of the variance in the dependent variable as caused by the independent variable, therefore the effect of conscious attentional focus on performance time in this experiment was both highly significant and substantial.

Table 4.2 shows the impact of conscious attentional focus on mean performance across each pair of experimental conditions. It is significant in all cases.

Table 4.2 Pairwise comparisons

(I) Focus	(J) Focus	Mean Difference (I-J)	Std. Error	Sig.[a]	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Control	Proximal	-1.42*	.37	.003	-2.38	-.46
	Distal	1.20*	.28	<.001	.46	1.93
Proximal	Control	1.42*	.37	.003	.46	2.38
	Distal	2.62*	.48	<.001	1.36	3.87
Distal	Control	-1.20*	.28	<.001	-1.93	-.46
	Proximal	-2.62*	.48	<.001	-3.87	-1.36

Based on estimated marginal means
* The mean difference is significant at the .05 level.
a. Adjustment for multiple comparisons: Bonferroni.

Bonferroni *post hoc* tests revealed a significant difference in surf ski sprint performance times between all trial condition interactions. The confidence intervals are .95 in all cases and are reported in the final two columns in Table 4.2.

4.7 Control of critical variables

As well as controlling for confounding variables, data were collected on several critical factors so that a *post hoc* statistical check could be made that this had been effective.

4.7.1 Trial order

Trial order was counterbalanced by systematically rotating all six possible order permutations so as to protect against any effect being as a result of the order. The next participant to volunteer was always placed into the next available configuration to avoid selection to enhance any desired outcome. This leaves only two or three participants in any particular trial order and this is insufficient to run statistical tests. It is reasonable with such an approach to assume that the counterbalancing was effective and there are no indications to the contrary.

4.7.2 Exertion, fatigue and training benefit

Participants' peak heart rates were measured (in beats per minute) during every trial. This served to assess whether exertion was related to trial condition or, alternatively, if exertion diminished over the trials thus indicating that fatigue may be having an impact. It was also possible that if exertion was related to trial order in either an increasing or decreasing manner, that this could indicate a training benefit – in the first instance because participants could exert more effort as they became increasingly familiar with the activity or, the opposite, because they became more relaxed and efficient with practise.

Table 4.3 Mean peak heart rates by trial condition

Trial Condition	Mean (beats per minute)	Standard Deviation	Number
Pre-test	144.4	20.2	20
Control	142.8	18.3	20
Proximal	140.0	18.7	20
Distal	145.5	17.6	20

The peak heart rates varied as can be seen from the standard deviation in each case, though there is a clear indication of greater exertion in the distal condition relative to all others. The proximal trial shows the lowest mean peak heart rate. These data correlate with the speed of performance results from each trial condition though contradict the subjective beliefs of the participants; the majority of whom thought the proximal trial to be the most effective. Only two of those taking part identified the distal condition as the fastest.

The pre-test mean is included as a natural comparator though any inferences must be restricted as neither the trial order nor visual focus was controlled for this run. It is interesting to note though that the distal condition was the only one to generate a higher average heart rate. This suggests that providing additional information in the experimental conditions (i.e. the verbal instructions) does not, in itself, impact on performance.

Table 4.4 Pairwise condition comparisons of peak heart rate means

(I) Mean peak heart rate	(J) Mean peak heart rate	Mean difference (I-J)	Std. error	Sig.[a]
Control	Proximal	2.80	1.60	.289
	Distal	-2.65	1.40	.219
Proximal	Control	-2.80	1.60	.289
	Distal	-5.46*	1.76	.018
Distal	Control	2.65	1.40	.219
	Proximal	5.45*	1.76	.018

Based on estimated marginal means
a. Adjustment for multiple comparisons: Bonferroni.
*. The mean difference is significant at the .05 level.

Mauchly's test indicated that the assumption of sphericity had not been violated, $\chi^2(2) = 1.30$, $p = .523$, therefore degrees of freedom required no adjustment.

The results show that peak heart rate varied significantly between the different attentional focus trials , F (2, 38) = 5.85, $p = .006$, $\eta_p^2 = .235$. The effect size (η_p^2 = .235), being greater than .14, is considered large.

Table 4.4 shows that the differences in mean peak heart rate are statistically significant only between the proximal and distal conditions ($p = .018$). No other interactions are significant ($p > .05$ in all remaining cases). There appears to be a correlation between experimental condition and peak heart rate which suggests that 1. Trial order did not have an impact. 2. There was no fatigue affect. 3. There was no training effect.

Overall, the mean peak heart rates are considerable bearing in mind that the average age of the participants was 55.4 years. The generally accepted maximum heart rate is 220 minus age (Tanaka *et al*., 2001) meaning that the mean maximum heart rate for this group would be 165 beats per minute. Taking into account that several of the volunteers in this study were at least 60 years old, Tanaka *et al*. suggest a more rigorous benchmark of 208 – (age x 0.7) for healthy, older individuals as they have found that the standard (non-scientific[24]) method tends to slightly underestimate maximums. If this formula is used with the mean age of 55.4 it increases the mean maximum heart rate to 169 beats per minute. The average peak heart rate across all trial conditions was 143.2 beats per minute meaning that the paddlers were working at between 84.6% and 86.7% of maximum depending on which method is used. This provides confidence that the participants did indeed attempt to paddle as fast as possible down the course and that any differences appear to be as a result of the trial conditions. It also indicates that the course was sufficiently long to highlight performance differences and to extend the participants fully without exhausting them.

4.7.3 Quantity of information

One of the experimental concerns in advance of this study was the potential impact of varied amounts of information being given to the participants before each trial. In particular, the potentially negative impact of increased amounts of

[24] Robergs and Landwehr (2002) explain that the 220 minus age method is not based on experimental data. Their article provides full details of the history of this formula and their concerns over its use.

information in the trials with a conscious focus provided. The proximal and distal conditions had comparable verbal information for the participants to contend with though the control trial had no conscious focus instruction included. The results from all the statistical analysis demonstrating the relative performance benefits of the various conditions does not show a deficit in relation to amount of information. This suggests that the information quantity was sufficiently well controlled between trials, had an insignificant impact or, that the conscious focus condition differences occurred despite any increases in information load relative to the control trial.

4.8 Qualitative statistics

The self-score, preferences and feedback from each participant were collated and are presented below.

4.8.1 Self-score

At the end of each trial run participants were asked to provide a self-score between 0 and 100 based on their view of their own performance. They were informed that they could use the score from their first trial as a benchmark around which they could provide scores in later runs. The pre-test was included so that the protocols remained the same and the participants did not realise that it was in any way different to the experimental trials. This data gave a clear indication of how they believed each performance compared and therefore the impact each condition had. The descriptive analysis is below. The full data set can be found in Appendix 1.7.

Table 4.5 Descriptive statistics for surf ski paddler self-score

Condition	Lowest self-score	Highest self-score	Mean	Standard deviation	Number
Pre-Test	15	70	44.60	14.74	20
Control	14	75	50.20	17.37	20
Proximal	5	75	49.00	19.62	20
Distal	7	75	49.15	17.81	20

Table 4.5 shows that the control condition was deemed to be the most beneficial in a performance sense. The proximal has a marginally lower mean than the distal condition. These means do not correlate with the timed performance data. This suggests that participants find it difficult to ascertain which of their performances actually are the best and which conditions are most effective. This data also gives confidence that the questioning directed at the paddlers between and after trials did not deflect them from their personal beliefs. It is also interesting to note the much lower self-scores in the pre-test – when the experienced paddler participants had complete freedom to think about and look at whatever they deemed suitable to enable fast sprinting.

4.8.2 Participant preferred condition

All participants were asked, after all trials were complete, to place the conditions into an order of preference (1 being most favoured, 4 being least favoured) and to provide reasons as to why. The pre-test was included so as to not identify that as a separate entity from the experimental conditions.

Table 4.6 Descriptive statistics for surf ski condition preferences

Trial	Lowest score	Highest score	Mode (number)	Mean	Std. deviation	Number
Pre-test	1	4	4 (8)	2.85	1.18	20
Control	1	4	1 (7)	2.05	0.95	20
Proximal	1	4	1 (8)	2.30	1.26	20
Distal	1	4	2 (9)	2.60	1.00	20

Table 4.6 suggests that the control condition was the most preferred on the basis of the mean. This matches the self-score information though does not correlate with the actual timed performance data. According to the mean scores, and excluding the pre-test, the distal condition was the least preferred which, considering that the distal performance times were significantly the fastest, indicates that the paddlers were either not making their choice on the basis of speed or, as seems more plausible, they found it difficult to identify which conditions were most effective.

The modal figure has been included as, with only four possible scores and twenty respondents, the mean could be misleading in cases where many participants respond, for example, with a 1 for any given trial though only one or two give the same trial a score of 4. The modal figures indicate that the control and proximal conditions were the ones most favoured by participants. Only two of those taking part listed the distal trial as their most preferred. This output and that from the self-scores does provide confidence that the data were not contaminated by experimental effects such as Halo or Hawthorne.

4.8.3 Participant comments on trial conditions

Participant comments were collected at the end of each trial run in regard to their performance and how they thought the condition affected them. A basic content analysis was conducted whereby similar comments were categorised and the total in each category added. The summary data are provided below, the full analysis can be found in Appendix 1.8.

Table 4.7 Positive and negative comments on each condition

Condition	Positive Comments (positive %)	Negative Comments (negative %)
Pre-test	8 (47.1%)	9 (52.9%)
Control	33 (84.6%)	6 (15.4%)
Proximal	42 (65.6%)	22 (34.4%)
Distal	23 (51.1%)	22 (48.9%)

Excluding the pre-test, which was included so as to not identify it to the participants as different, the proximal condition has received the highest number of positive comments – almost double that received by the distal focus. The distal and proximal conditions have the same number of negative comments. The control condition shows the largest disparity between positive and negative comments whereas the distal condition has received a balance of each.

These data appear to match the other subjective information gathered and indicate that the control and proximal conditions were the most positively regarded. This again suggests, that participants are not easily able to discern the factors which are most beneficial to their performance. Their prior experience may have led them to erroneously identify issues they believe to be helpful which, in reality, are providing no benefit, are detrimental or which are not relevant.

4.8.4 Participant focus in pre-test and control trial

In addition to asking about the paddlers' feedback in relation to each condition they experienced, they were also asked what they actually focused on or thought about during the pre-test and control trial (immediately after each of these runs). It was thought that this may provide insight into participants' focus in non-constrained situations and assist in explaining any performance differences. Table 4.8 shows the number of comments that indicated an internal, proximal and distal focus in the pre-test and control trial. The full analysis and example comments can be found in Appendix 1.9.

Table 4.8 Self-selected conscious focus in the pre-test and control trial

	Internal Conscious Focus	Proximal Conscious Focus	Distal Conscious Focus
Pre-test	21	18	0
Control Trial	6	11	0

The above data suggest that, when no conscious focus was provided or required, that participants are very likely to think about their body, equipment or immediate surroundings. No-one reported thinking about a goal or distal point. This may explain why the participants provided higher self-scores and stated a preference for the control and proximal conditions compared to the distal trial.

4.9 Additional analyses

As mentioned in Section 4.6, the opportunity to examine sub-groups within the data set does exist and this may provide indicators for future studies. In Study 1 the most obvious sub-sets to evaluate was prior experience of paddling the craft as there equal numbers of experienced and inexperienced surf ski paddlers within the participant group.

4.9.1 Prior experience

Table 4.10 below provides descriptive statistics of those with and without prior boat specific experience before the trials. The mean values suggest that, whilst in all conditions those with experience were faster on average, the relative benefits to performance of each trial condition were similar for both groups. The distal focus produced the fastest times, the proximal trials the slowest (the nine slowest performances were those of the nine participants with no prior experience). The range of scores was also greater in the group with no prior surf ski experience.

Table 4.10 Prior surf ski paddling experience by experimental condition

Condition	Prior surf ski experience	Mean (seconds)	Standard deviation	Number
Control	No	34.89	6.16	9
	Yes	27.73	2.43	11
	Total	30.95	5.69	20
Proximal	No	36.22	6.94	9
	Yes	29.22	2.98	11
	Total	32.37	6.14	20
Distal	No	33.26	5.32	9
	Yes	26.89	2.14	11
	Total	29.75	4.99	20

4.10 Discussion

The results from this study demonstrate a significant benefit to performance of using a distal conscious focal point relative to both a proximal focus and no defined focal point in surf ski sprinting. In addition, the no-focus control condition produced significantly faster performances than the proximal conscious focus trials. In all pairwise interactions (i.e. between the individual conditions) the level of statistical significance was very high (all p values < .004). The size of the manipulation effect was likewise large ($\eta_p^2 = .551$). These findings provide clear evidence that distance of conscious focus may have a sizeable impact on motor performance and moving it further from the body is more effective. Whilst these results reinforce the distal focus benefit found in the small number of other attentional focus distance studies conducted to date (e.g. Park *et al*., 2000; McKay and Wulf, 2012; Porter *et al*., 2012), they also extend current knowledge by demonstrating a focus distance effect in an applied continuous skill for the first time. The few previous studies into this type of skill employed the more standard internal – external - control format (e.g. Freudenheim *et al*., 2010; Stoate and Wulf, 2011).

The skill used (surf ski paddling) was a further novel adjunct to the body of research in that paddle-sports had never before been assessed in this academic domain and the use of a very large piece of equipment is unique in the attentional focus research field. In addition, this is also the first study to directly compare a proximal focus with a distal focus i.e. two different external points, with the primary goal of assessing their impact on performance. The inclusion of a no-focus trial condition further enabled a distinction between the potentially beneficial and detrimental effects of a directed focus relative to an unconstrained situation.

The distal focus benefit found in this experiment indicates that a defined and directed external point of attention is superior to all others. This is consistent with almost all previous conscious focus work (e.g. Park *et al*., 2000; Wulf *et al*, 2004; Marchant *et al*., 2009: Lohse and Sherwood, 2012); it extends current knowledge on the effect of external focus distance on motor performance. However, the finding that a proximal external focus was significantly less effective than the participants' self-selected focal points is unusual. Taking these two outcomes in turn, the Constrained Action Hypothesis (Wulf *et al*., 2001; Wulf and Lewthwaite, 2010) can be deployed to explain the distal focus advantage in relation to the control trial. Removing the paddlers' attention from the mechanics of their physical movements and the orientation of their equipment, instead placing it on a fixed and external point, left their natural ability to move, both effectively and efficiently, unfettered. In contrast, a focus on controlling the boat's stability seems to have actually undermined performance relative to the control trial in the same manner that has occasionally been reported for an internal focus (e.g. Marchant *et al*., 2011). This is an uncommon finding and may indicate that in activities in which a large and complex piece of equipment has to be propelled with the athlete on or in it, a focus on that equipment may cause a dramatic decline in performance – perhaps conscious focus is redirected to stability and the movement mechanics of both body and equipment. This possibility is worthy of future investigation.

An alternative interpretation to the one above, not previously advanced, is that in situations where the performer and their equipment could be viewed as a single entity, such as paddle-sports or motoring, then perhaps that equipment acts as an extension of the body. It may be therefore, that the attentional effects found with a proximal focus in the present work are akin to those commonly reported with an internal focus. Imagining the impact of focusing on the manipulation of the handlebars whilst riding a bicycle, the fine motor control of which is critical to stability and direction, indicates how this could provide both less effective motor movement as well as a crucial distraction from the riding environment. An example from canoe-sport would be eddy turns in white water kayaking: the commonly encouraged and deployed proximal focus to think about the boat's edge (raising the upstream edge permits a stable, carved turn) requires paddlers to attempt to consciously assess and apply an appropriate amount of tilt. This judgement of 'edge' is not only difficult, particularly for novices, it may also prevent the participant from considering timing, position and direction in an open skill context and may therefore detrimentally affect paddling skill. See Banks (2001a) for further discussion on the potential effects of different focus points in the performance of this skill.

Based on the present study, as well as significant personal experience, it seems likely that a proximal focus in situations in which the performer and equipment operate as a single entity, may operate to constrain subliminal control, reduce degrees of movement freedom and undermine performance. There is clearly a spectrum of equipment-performer synthesis from a 'tool' or implement to equipment which the individual, in effect, 'wears'. Notwithstanding the point on such a spectrum at which any conjoining of an internal and proximal focus may take place, this supposition has not been postulated before. Such an effect cannot be assumed in the present study, though the findings do suggest that the possible interaction between participants and their equipment is worth considering and investigating further – with the addition of an internal focus condition for comparison.

Other theoretical positions seem to offer less effective explanations for the results seen here. For example, Willingham's (1998) Control Based Learning

Theory (COBALT) would suggest that an internal focus on the body would generate a performance detriment relative to both an external focus and a no-focus control situation. The conscious bodily control mechanism Willingham proposes is theorised to disrupt and slow subconscious organisation (see Chapter 2, section 2.4.2 for a full explanation). This hypothesis does not predict or explain either an external focus advantage or disadvantage compared to a no-focus performance – both of which occurred here. If the above argument that the proximal trial became, in effect, similar to an internal focus in the response it produced, then that would correspond with the anticipated detriment observed in this study. However, the COBALT neuropsychological theory of motor skill acquisition would not envisage the distal focus benefit measured in the surf ski experiments. Furthermore, the Explicit Monitoring Hypothesis (Beilock and Carr, 2001), which emerged from Willingham's (1998) theory, also forecasts that novices may profit by attending to movement mechanics in the early stages of learning a novel task whereas experts will be disadvantaged in line with COBALT expectations. The evidence from the present study does not support either of these assumptions as there is no difference between the relative attentional effects on novices or experts in the surf ski trials (Table 4.10).

In the current study the significantly faster performances recorded under the no-focus control condition in comparison to the proximal external focus are surprising. As Wulf (2013) points out, few prior studies have ever found a control trial benefit over any form of external focus – her balance experiment with the *Cirque du Soleil* acrobats being a notable exception (Wulf, 2008). In that study the expert performers exhibited significantly superior balance when they were allowed to select their own focal points thus indicating that they had already reached a level of optimisation that could not be surpassed. Unfortunately, the acrobats were not questioned on what they actually focused on in the control condition, though in the present study the surf ski paddlers were asked for that information after both the no-focus trial and the pre-test (see Table 4.8 and Appendix 1.9). Interestingly, in every individual case on both those runs in the present study the participants reported thinking about either their bodily movements (internal) or their equipment (proximal). None of the surf ski paddlers involved in this work reported focusing on any point which could be considered distal at any time. Bearing in mind that all the participants were experienced and competent paddlers and half of them had spent significant time in surf skis, it seems very odd that they would not consider a more distal focus. On questioning them they commonly claimed that focusing on their form and technique was crucial and it seems that this is what they have been led to believe, been coached to do and what they have become adept at using (Appendix 1.9 summarises participants' comments).

Personal experience and much of the specific written advice and course content for canoe-sport coaches (e.g. Ferrero, 2006; Davey, 2009; Holland, 2013) indicates that trainers do usually focus their charges' attention on such internal and proximal factors. It was certainly the case in the United States that the regularly observed coaching input was centred on movement technique (body and equipment) rather than effective and adaptable manoeuvres. Bearing in mind the high average age of the paddlers encountered in California and the fact that for most of them canoe-sport was an activity which they had come to later in life, they are perhaps more dependent on coaching input and may be less trusting in their own ability to develop effective skill without in-depth knowledge of the technique. An alternative explanation for this desire to focus on the mechanics may be that their prior experience of learning skills, particularly physical ones, has led them to believe that such a technical 'building block' approach is the most effective and, indeed, is required if they are to progress. In order to confirm these anecdotal suppositions it would be necessary to conduct further investigations, though the strength of the participants' belief in, and the unanimous choice of, such a focus when the trials allowed was striking.

An internalisation of focus is clearly common across a range of disciplines as Porter *et al*. (2010a) highlighted in their study of track and field coaching approaches. It may therefore be the case that the participants in this study required less cognitive effort when permitted to choose internal and proximal focuses that they were familiar with than when required to use a single proximal point for the duration of that trial. This would not be a unique occurrence as Maurer and Munzert's (2013) study with young, national standard, German basketball players found that when they selected their preferred internal focal points they were not disadvantaged. It was also the case with these basketball players that their coaching input had predominantly encouraged an internal focus which seems likely to have led them to believe in the value of such an approach.

Research studies such as the present one and those above do not typically have the facility to run long-term experiments to assess whether, given time, instructed attention or deeply embedded preferences for any particular focus may be overcome by others which are usually found to be more advantageous (a recent exception being Guillot *et al*., 2013). It would seem though, in the case of the surf ski paddlers in the current study, that their familiarity with internal and proximal focal points coupled to a strong belief in their efficacy, may have led to a superior performance under the control condition than in the fixed focus, proximal external trial. The lack of longitudinal data prevents us from knowing whether or not this would persist over time. Whilst this is an unusual result and does present further opportunities for study, it also demonstrates that the distal attentional focus benefit is very potent even in the face of a favoured and well practised conventional approach.

The additional analyses of the data in the current study produced some interesting results, not all of which match previous findings. The resting and peak heart rate monitoring was initially included to ensure participants recovered between trials and were not tiring as they progressed through them. It also served the purpose of providing a useful ‘red herring’ to distract those taking part away from the true purpose of the testing. Based on the data collected and comments made by participants in relation to heart rate it did achieve these goals effectively, it also indicated that peak heart rate is linked to focus and, indirectly, speed in that the distal times were significantly faster and the more quickly individuals paddled the higher their peak heart rate. Whilst there was only a statistically significant difference between the distal and proximal conditions (Tables 4.3 and 4.4) – the fastest and slowest respectively, previous studies have found that an external focus resulted in more energy efficient movement – often with coincidental performance improvements (e.g. Vance *et al*., 2004; Zachry *et al*., 2005; Wulf *et al*., 2010a). In those studies though, the level of exertion was either low or of an anaerobic variety, and the removal of internally focused conscious control via an external focal point was found to significantly reduce the antagonistic muscle co-contraction (e.g. Lohse *et al*., 2011).

The surf ski paddlers, conversely, were engaged in an aerobic task in which they were significantly faster under the distal directions. It appears therefore, that the removal of the potentially constraining focus on the equipment and, instead, being required to use a directed focus on the target, has enabled the paddlers to exert more effort more effectively thus resulting in higher peak heart rates. Interestingly, the proximal focus generated the lowest peak heart rate which seems to suggest that a focus on the boat diverted the participants from effortful sprinting or hindered their ability to work maximally. As performance was so negatively affected under the proximal condition it cannot be argued that the lower heart rates in this trial equate to greater efficiency and movement economy. Were this actually the case then performance in the proximal trial would equal or better that in the distal trial though with reduced effort.

One final point worth making on this subject is that the pre-test heart rate mean was the second highest (behind the distal focus run) even though it produced times slower than the control trial. Whilst it must be borne in mind that the pre-test was not controlled for trial order or vision, it does suggest that a directed focus, especially a distal one, may reduce peak heart rate; this would be in accord with Schücker *et al.*'s (2009) aerobic exercise finding whereby an external (arguably distal) focus improved motor respiratory economy in a treadmill running task. Additionally, the heart rate findings suggest that the information provided in the trial conditions did not adversely affect the participants. Future studies may include other physiological measures, such as electromyography, VO_2 max and blood analysis to better understand the impact of focus on muscle metabolic and economy of movement factors.

Whilst no biomechanical measure of movement efficiency was included in this study, several of the participants reported, when questioned, that they felt the distal focus was detrimental to their technique and/or the proximal focus was the most effective for, or helped maintain, their form. It is clearly the case that a distal focus produced significantly faster times but is it possible that this could have been despite a decline in movement efficiency as some participants suggested? One way to investigate this would be to conduct kinematic tests of paddlers under the same or similar conditions as used here; this is worthy of further study. It might be the case that with greater effort individuals may push themselves closer to their physiological limits and their technique may start to deteriorate as a result. Whilst the participants in the current study did exert themselves more in the distal condition the difference was not large – no-one became exhausted or required lengthy recovery.

In my long experience of coaching paddlers, an apparently effective way of improving posture, catch (paddle entry point), cadence, power delivery and timing has been to vary the speed and force which they apply, with a particular emphasis on short sprints or elevated effort over a longer period. This typically improves their technique insofar as posture becomes more upright, which in turn allows a steeper and further forward paddle entry and exit point followed by a more rapid recovery and therefore higher cadence. Clearly, a scientific measurement would be required to confirm this though there seems no reason to believe that in the present study technique and efficiency suffered as a result of a distal focus – possibly quite the opposite.

The information gleaned from the participants in the form of performance self-scores, trial preferences and their comments on each condition demonstrate a lack of congruence with their actual timed runs. At the end of each sprint (including the pre-test to maintain consistency) the participants were asked for a performance self-score between 0 and 100. The results showed they believed the control condition was the fastest on average with only a negligible difference between the distal and proximal trials (Table 4.5). This demonstrates several points: the participants were not able to accurately gauge their own performance; their judgement over what is most effective cannot be relied upon and therefore accurate and objective measurement is important. It seems their beliefs did not affect their actual speed or effort under the different conditions, and the questioning between trials did not lead or deflect them from their disposition. Taking into account that some of the differences in speed between trials for any given participant were quite large, it is surprising that the self-scores were so inaccurate. Whilst it is possible that the marks reflect their expectations, this was not apparent at the time; indeed, it was universally the case that the participants carefully considered all their answers. This brings into question any reliance on participant judgement in a performance environment which is not supported by objective measurement. If performers are not capable of identifying effective output it seems that coaches and trainers may likewise suffer the same difficulty. As the common approach to attentional focus in performance seems to direct it internally or proximally (e.g. Porter *et al*., 2010a) this may pre-empt subjective decisions on quality and effectiveness.

As well as self-scores the participants were further asked to choose an order of preference for the four sprints; this also produced interesting responses. In line with the self-assessment above, the control trial was the most preferred with the proximal condition second most favoured. The distal trial was third just ahead of the pre-test - which was included so as to not identify it as a separate entity (Table 4.6). Bearing in mind the dominant nature of the distal external focus in producing the fastest performances it seems strange that it was not more highly regarded. In fact, only two of the twenty participants listed it as their most preferred run when for eighteen of them it had been their best sprint. Whilst their responses were due, in part, to factors other than speed (see Appendix 1.8), considering that going fast was the whole point of the exercise, it would appear again that individual performers find it very difficult to discern which circumstances are most advantageous to them.

The summary of participant comments (Appendix 1.8) shows their assessment of each condition and demonstrates how difficult it was for them to assess benefit from personal analysis and expectations alone; the latter may, in fact, have acted to mislead them. When the current prevalence of and emphasis on learning styles is considered, this adds to the academic position (e.g. Pashler *et al*., 2009; Reiner and Willingham, 2010; Leevers, 2014; Banks, 2011) that learner preferences cannot be depended upon to correlate with the most effective learning and coaching strategies. Had the surf ski sprinters in the present study been permitted to select a method for their own training and performance enhancement from the conditions they experienced, 90% would have made the wrong choice.

A factor which has been much debated in the attentional focus literature is that of expertise and prior experience (e.g. Wulf *et al*., 2002; Beilock *et al*., 2002; Wulf and Su, 2007; Bell and Hardy, 2009). Whilst no hypothetical position was advanced on this topic beforehand and the study did not set out to evaluate it, the results demonstrate no difference in focus benefit between those with and without prior surf ski experience. Whilst the mean times were approximately seven seconds slower for those novice in the craft, the relative benefit of focus remained consistent between the two groups (Table 4.10). Perkins-Ceccato *et al*., (2003); Casteneda and Gray, (2007); Beilock and Gray, (2012) and others have conducted studies which suggest that an internal focus for novices is superior to an external point. These have been criticised for using ambiguous or overwhelming instructions or for evaluating the impact of distraction on performers rather than ascertaining the effect of conscious focus primarily (Wulf, 2013). The current study found no support for the notion that expertise is a factor affecting attentional focus benefits; to this end it supports the more commonly reported outcome that an external focus is advantageous whatever the competence level (e.g. Thorn, 2006; Marchant *et al*., 2007; Nafati and Vuillerme, 2011; Wu *et al*., 2012). Furthermore, it extends previous work by suggesting this is also the case when the focus distance is manipulated.

One remaining personal factor which has previously been studied in regard to attentional focus is age (e.g. Caserta *et al*., 2007; Wulf *et al*., 2010b, Chiviacowsky *et al.*, 2010. In the present research no deliberate assessment of this variable was considered or included in advance therefore any observations should only be used to stimulate further work. In the current investigation the average age of the participants was high – particularly considering the effortful nature of the activity. It is interesting therefore, to reflect that the benefit of a distal focus was so strong with such a group though, as previously mentioned, they found it very difficult to assess their own performance and did not favour the distal condition. This, of course, makes the outcome even more notable, further demonstrates the universal nature of attentional focus effects and is consistent with the results of the studies above. From the point of view of future work, it would be interesting to run separate studies to assess any differences in distal focus effects on participants from distinct age groups.

4.10.1 Summary

Overall, the results of this study provide clear evidence of the benefit of a distal external attentional focus in an applied continuous skill in a relatively closed skill performance environment. Participants from a range of backgrounds and ages took part, there were equal numbers of men and women and of individuals with prior surf ski experience or not. The participants formed a representative sample of people who canoe and kayak in Southern California and, one could confidently claim, of paddle-sport enthusiasts in any country and territory where the activity takes place and coaching is available. It seems reasonable to suggest these outcomes are likely to be replicated wherever this type of study could be run; these results and their potential generalisability should therefore be attended to by coaches and learners in canoe-sport. In addition to this, it also appears reasonable to expect these findings would be reproduced in other continuous skill domains as there is nothing to warrant the belief that an alternative attentional focus would be more advantageous.

From the point of view of teaching and learning these results provide encouragement to those who would focus attention on the required outcome or target which they wish to attain. There is no support here for a conscious focus on either the body or the equipment. Indeed, in line with Wulf and Lewthwaite's (2010) updated version of the Constrained Action Hypothesis, a more distal focus appears able to concentrate and limit a learner or performer's thoughts on a positive and appropriate point whilst at the same time distracting them from deliberating over movement mechanics. This approach seems likely to permit the body to naturally self-organise in a more optimal fashion. The current study extends knowledge and understanding of attentional focus effects and provides a platform for further work into this phenomenon. In particular, expanding research to examine distal focus effects in different populations (e.g. novices, experts, children), different skill types (open, serial), a range of activities (particularly those which require the participant to be conjoined to large equipment) and with a variety of distances and instructions, should assist in identifying more optimal points. Should the logistical challenge be surmountable then using a between-groups design so as to be able to run retention and transfer tests will provide useful information on the persistence of any benefits.

This study has tackled the issue of conscious attentional focus in a novel sporting skill and has examined the effect of distance on performance. It develops knowledge and understanding by providing results from an applied, continuous kayaking skill – a paddle-sport was studied for the first time and a large piece of equipment was employed in an experiment for the first time. It also strengthens the evidence base for an external focus advantage and demonstrates that focus distance is influential, perhaps even critical, in motor skill performance. The current work provides a foundation for several further research projects as well as repeat work across a range of disciplines to verify these findings. The implications of these results for performance and coaching are self evident: both learners and their teachers and trainers should consider more restricted conscious focuses which are more distant from the body. The present study further suggests that an external focus which is proximal to a performer may, under certain circumstances, be disadvantageous compared to a self-selected focus. As this research stands, it is immediately relevant to both performers and coaches and adds to the weight of academic evidence demonstrating attentional focus effects. It will, hopefully, begin to permeate into and influence teaching and learning practice in paddle-sports and beyond.

Chapter 5

Study 2

5.1 Introduction

Following the significant distal focus benefits which were apparent in Study 1, a natural extension of that study was the assessment of a group of people who train and compete in a specific closed skill in which the repetition of a technique to a high degree of perfection is required. Specifically, as with the previous study (Chapter 4), this would need to evaluate the impact of a proximal versus a distal conscious focus of attention with a control condition in which no conscious focus was stipulated.

During the time spent in San Diego (May to August 2011) many paddlers and coaches were encountered. This included Chris Barlow, 1992 Olympic K4 sprint kayaker and now Head Coach of the San Diego Canoe and Kayak Team (SDCKT). The team specialises in sprint kayak training and racing and has a significant cohort of talented, junior paddlers. Many of the young kayakers compete successfully, with some reaching national standard.

Sprint kayaking is a technical discipline and a continuous skill in which the ability to reproduce a fixed action pattern to a high degree of perfection is required. The only variables which can directly impact on the performer are wind and water conditions. Most racing and training areas are inland on sheltered water and therefore these factors tend to be reduced to a minimum. In any case, if they exist they are likely to be constant, and if conditions are too challenging then racing will not be possible. Sprint kayaking is a closed skill relative to most other activities and forms of paddle sport. Appendix 2.1 (Figures 2a, 2b and 2c) shows images of the boat with further information.

Following discussion with Chris regarding the need for experimental participants he kindly agreed to allow access to some of his junior sprinters as part of their coaching and training programme. Chris programmed time over several weeks so that different, small groups of athletes could be worked with at the start of evening training sessions. At no point was Chris provided with any information about the purpose of the testing or the field of study. It was explained that everything possible had to be done to eliminate or prevent contamination of the participants' work by them inadvertently discovering any part of the research in advance of their taking part. This stance also prevented knowledge of the study influencing Chris' decision on which kayakers would be chosen or allowed to take part in the study, though I did request that they be competent sprinters as a minimum.

5.2 Pilot study

Personal, recent experience of running an attentional focus study in sea kayaks (Banks, 2009) as well as Study 1 using surf skis (Chapter 4) had informed the experimental approach. Notwithstanding this, and before committing to a set of protocols, it seemed wise to ascertain a suitable sprinting distance in advance as well as to run a small group of kayakers through a pilot study to check that everything worked as expected.

Following discussions with Chris Barlow it transpired that competitive distances comprised 200m, 500m and 1000m sprints with the 200m distance being common for juniors. The 200m distance was introduced as an Olympic discipline for the first time at the 2012 London Olympics – incidentally, an event in which Great Britain's male competitor won Gold. Chris also advised on typical times for such a distance, though bearing in mind the potential fatigue effect of sprinting this course length multiple times, coupled to the time needed to sufficiently recover, 200m was deemed too long. Following Chris' expert advice that sprinting 100m could be achieved without undue fatigue, and several minutes of rest would be sufficient to recover, this distance was adopted for the trials. This decision was supported by Hebestreit *et al.*'s (1993) research which evaluated recovery after 30 seconds intense cycling activity in men and boys. They report that boys' mean power returned to 89.9% of the pre-exercise value after 1 minute of rest, to 96.4% after 2 minutes and to 103.5% after 10 minutes. The participants in their study were matched for physique and fitness but were not chosen for their athleticism and were not cyclists.

As the young participants in this sprint kayak study follow a structured training and racing programme in which their performances are constantly monitored, it is fair to say that they were both technically competent and physically fit in the discipline. It therefore seemed that 100m would not unduly stress them and the fact that they had between 5 and 10 minutes between runs should provide sufficient time to recover to full power capacity. This course length would also provide sufficient distance to identify any performance differences between the trials, bearing in mind the high speed with which this boat type could cover the water. Once the distance had been established the first programmed evening was run with four young paddlers with an eye to effective and rigorous procedure as well as on conducting speed trials. Had anything occurred which required alteration to the protocols then these participants would not have been included in the data set.

5.3 Experimental design

5.3.1 Participants

Eighteen sprint kayakers, all members of SDCKT, volunteered to take part in the study. Sixteen were under 18 years of age whilst two were 19 years old, the youngest was 12. The mean age was 14.7 years, the standard deviation was 1.91. Appendix 2.2 provides participant age, gender and trial order.

5.3.2 Ethics

Due to the club and team environment in which the experiments would be taking place, coupled to the age of the majority of participants, it was necessary to ensure that either the parents of juniors, or the team, which was acting in *loco parentis*, provided informed consent for the study to go ahead. It was explained to Chris Barlow that the kayakers would need to warm up as normal and then sprint 100 metres close to the shore three times following instructions provided by me. These sprints would be punctuated by a resting period. At no point would the kayakers be beyond easy reach and assistance should it be needed. Following this discussion Chris was happy to enrol me as a coach with the team for the duration of the work so that the experiment would be conducted whilst working under their auspices. The team held all relevant permissions and medical information.

Being officially recognised as a coach entailed me joining both SDCKT and the United States Canoe Kayak Team so that appropriate insurance coverage to work with the young people would be in place. Full insurance cover had also been confirmed by the British Canoe Union for professional indemnity and research whilst in the United States. My current coaching qualifications were also acceptable to SDCKT. This meant that formal, written permission from individual participants or their parents was not required. Whilst Chris provided kayakers to work with, in order to ensure the best ethical practice, and also to make sure that only motivated individuals participated rather than ones who had been instructed to do so, each individual was also informed of the basic structure and requirements of the study and their personal permission obtained to include them in the research. It was clearly explained to everyone that they should not take part if they did not want too. They were also informed that they could withdraw at any time if they no longer wished to be involved and that they were under no pressure to continue should they change their mind about participating. All the paddlers were assured that they and the data relating to their participation would be anonymised throughout the study. Verbal permission was sought to record their performance on video and on paper. In the event no-one chose to withdraw. The full participant briefing which was used can be found in Appendix 2.3.

5.3.3 Equipment

Due to the specialist nature of sprint kayaking, paddlers choose the equipment that is most effective and well fitting for them. All the participants therefore used their own boat and paddle. No buoyancy aids were used as these do not form part of the equipment for this activity. Due to the temperate weather and warm, shallow water only lightweight clothing (shorts, vests, T shirts) was required; no-one was permitted to change their equipment or clothing part way through their tests. See Appendix 2.1, Figure 2a, 2b and 2c for further information on the craft and images of a sprint kayak.

Experimental equipment comprised exactly the same camera and tripod as used in Study 1 (Chapter 4). A thin, vertically placed stake was used to provide the finish point so that it would be virtually invisible to the paddlers but would provide a transit and clear timing point for the videographer (Appendix 2.1, Figure 2d). The start was marked by a cone on the beach and by a tethered buoy in the water. The distance was judged using a pre-measured 100m length of twine.

Participant information sheets were present so that they could be read out in advance to all those taking part. A clipboard and individual participant data sheets were produced to record all pertinent information during and after the trials (Appendix 2.4). No safety kayak was required as it was always possible to simply wade in and provide assistance to anyone who required it. A first aid kit was always to hand.

5.3.4 Venue

The San Diego Canoe and Kayak Team base was used for the study. SDCKT is located on the shore of Enchanted Cove on Fiesta Island[25]. San Diego benefits from a small temperature range, low average wind speed and very little precipitation, this leads to predictable and consistent conditions which are ideal for sprint kayaking[26].

The waterfront facing SDCKT was used for the trials. This comprises a long, straight stretch of sandy beach with shallow, warm water beyond in an almost enclosed basin. Water temperatures in June and July in deep water off San Diego Bay average 21.4°C with a range of 21.3°C to 21.7°C[27]. Inshore, and especially in shallow basins with little water circulation, this may be several degrees warmer and very consistent; such warmth would cause expansion and reduced viscosity thereby being potentially beneficial to kayak speed as drag is reduced. A 100m section of beach was measured out where there was the least likelihood of disturbance and where the siting of start and finish markers as well as the high definition video camera would be straightforward. This was done using a pre-measured length of twine.

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[25] The address of SDCKT is San Diego Youth Aquatic Centre, 1750 Fiesta Island Drive, Mission Bay, San Diego, California.

[26] Average temperatures for June and July are 19.3°C and 21.7°C respectively; wind speeds for the same months average 7.8mph and 7.5mph whilst precipitation for June is 0.25cm with an average of 0cm in July. The following link provides comprehensive meteorological information on San Diego http://www.climate-zone.com/climate/united-states/california/san-diego/index_centigrade.htm

[27] Sea temperature information can be found on the United States National Oceanographic Data Centre's website http://www.nodc.noaa.gov/dsdt/cwtg/spac.html

The trial course was approximately 10m from shore so that sufficient depth existed to prevent friction caused by displaced water waves being contained and exacerbated by the sea bed. The approximate depth (estimated by wading out) was 1 metre throughout the course; the depth remained constant during the trials despite tidal fluctuations as I always waded out to the same depth. Sprint kayaks are designed to have minimum viscous friction, maximum laminar flow and to produce the smallest possible waves (Appendix 2.1 shows images of sprint kayaks). This means they can operate in more shallow water than most vessels without noticeable drag. None of the study participants commented on unusual drag and all followed exactly the same trial course so any such resistance would have been equal for all. Whilst the physics of boat design in relation to drag is well understood (Armenti, 1985), there appear to be no scientific studies detailing the actual depths at which such friction slows a variety of boat types and designs. Armenti does suggest that a depth of 1.05 metres should produce the minimum drag for a racing kayak of 4.5 metres in length and explains the physics to support this.

5.3.5 Environmental hazards

The waters in the Mission Bay area, including around Fiesta Island, are partitioned for different types of activities. Therefore, whilst other kayakers, canoeists and dinghy sailors could potentially be in Enchanted Cove no motorised vessels of any kind are permitted. In reality, in the evening it is uncommon for any water users other than the SDCKT members to be present, and their coaches were aware to provide plenty of clear water so as to not impede, distract or interfere with the experiment or its participants (see Appendix 2.1 for images of the venue in use). The only other significant hazard was Round Sting Rays (*Urobatis halleri)* as they prefer exactly the type of sandy bottomed sea bed present around Fiesta Island. The venom from these animals produces an extremely painful sting and therefore anyone in the water is at risk. I was most in jeopardy from this potential occurrence due to having to wade into and stand in the sea to hold the sprinters before their runs and to brief them on the task for each run.

5.3.6 Staff

In addition to being responsible for the organisation, set up and safety of the study I also briefed all the participants and controlled the start of each run (see Appendix 2.1, Figure 2b). A parent acted as recorder, following a careful briefing, and a professional photographer operated the video camera.

5.4 Control of variables

Given the naturalistic format of the study there was the potential for a range of variables to confound the results, these were controlled or assessed as follows:

5.4.1 Trial order

Trial order effects were controlled in exactly the same manner as in Study 1 (Chapter 4). Appendix 2.2 shows the trial order for each participant.

5.4.2 Vision

Visual attention was controlled across all trials in exactly the same manner as in Study 1. The same post trial checks were deployed to ensure this had been effective.

5.4.3 Modelling

This was not deemed to be a significant issue as all the participants had sufficient experience and training to be able to sprint without recourse to copying their peers. They also regularly trained and practised together so would not be seeing anything new or unusual that would affect their paddling.

5.4.4 Fatigue

The group taking part in the study comprised young, athletic and fit individuals who train and compete in this discipline; they follow a structured and well monitored practise and competition programme. The trial run was 100m – half the shortest competitive distance. After each run the paddlers were asked to gently kayak back to the start in a wide arc away from other participants. There were at least five minutes between runs which provided ample time for complete recovery (Hebestreit *et al.*, 1993; Ament and Verkerke, 2009). No heart rate monitoring was used as sufficient equipment to monitor multiple performers was not available. To constantly transfer the heart rate equipment between paddlers was deemed too cumbersome and seemed likely to slow the process down to a point where they may become frustrated and disengaged. The time gaps for recovery between runs were greater than in Study 1 (Chapter

4) due to the number of participants taking part in any given session, this provided reassurance that heart rates would have returned to the pre-trial level. The actual timings and timing gaps between runs were recorded on the video camera. Whilst heart rate monitors could have provided extra information which may have been used to avoid fatigue, to compare energy expenditure under different trial conditions and to distract participants from identifying the purpose of the study, in reality the existing protocols and the within-participants design appear more than adequate and are in line with most other study designs – the use of heart rate monitoring is an uncommon addition to experimental protocols.

5.4.5 Training effect

The trial order counterbalancing had the additional benefit of allowing the identification of any training benefit from the first to the third run. However, due to the nature of the performers and the fact that they train several times per week in this discipline, it was unlikely that they would improve significantly over the three short runs of the study.

5.4.6 Trial briefings

Trial briefings were conducted in the same manner and on the same basis as in Study 1. The instructions used can be found in Appendix 2.4.

5.4.7 Expectations

In a study such as this, using young athletes, it appeared reasonable to assume that a variety of participant effects might affect their effort and performance as they strove to demonstrate their competence or even subconsciously assist the researcher e.g. HALO, Hawthorne and Pygmalion (Rasmussen, 2008; Rosenthal and Jacobson, 1968). Measures and checks to control information about the experimental purpose as well as to assess expectations and perceptions of the various trials were the same as those deployed in Study 1. These were recorded on the individual data recording sheet (Appendix 2.5). The use of self-scores as a means of gathering qualitative data to evaluate participant perception and to check conditions have been adhered to is clearly reliant on the ability and integrity of the participants, though there is no reason to believe they deliberately provided false information.

5.4.8 Environmental conditions

As sprint kayaking is a flat water discipline sizeable waves can deflect and swamp the boats whilst wind can make them unmanageable. The environment used was sheltered from significant waves (10cm maximum) due to the short fetch in Enchanted Cove (c300m to the windward shore from the trial venue) and low wind speed (Beaufort Force 3 maximum) – the conditions were the ones in which the paddlers regularly trained and practised. A section of beach was used which was away from the main activity centre and free from people and distractions; other users were either prohibited or kept at a distance by the SDCKT staff. Any environmental variation e.g. wind, remained constant across an individual's three runs. The wind conditions rose to Beaufort Force 3 maximum (11 mph) and were always from the west. As a result of this all trials faced the wind to prevent the need to steer (paddling into the wind is the most directionally stable method). The tests were always run at the same time in the evening so conditions were as similar as possible and any onshore breeze had diminished; incidentally, chronobiological research into the impact of circadian rhythms on athletic endeavour suggest that early evening is the optimal time for human performance as it coincides with peak body temperature (see Drust *et al.*, 2005, for a review). Appendix 2.1, Figures 2b and 2c provide images of a participant during the actual experiment.

5.4.9 Information sharing

Information sharing was controlled in the same manner as in Study 1.

5.4.10 Equipment control

All the participants used 'best fit' equipment for them rather than being required to use the same equipment. For these particular individuals it was judged that insisting on the use of identical equipment would provide an unequally distributed handicap.

5.5 Method

As with Study 1 a within-participants design was employed - for the same reasons as explained in Section 4.5, p? The speed trials comprised three separate sprints of 100m.

On meeting each group of paddlers and following introductions, the briefing was read out to them and they were given the opportunity to withdraw. It was emphasised to them that the choice to participate was theirs alone and they could change their mind at any time. Once suitably equipped and ready, the participants (maximum 4 per evening) were invited to follow their normal warm up routine and then to meet in the designated area (holding area). This usually took 10 – 15 minutes.

Once they arrived in the holding area the participants self-selected their order, i.e. who would go first, second etc. – this again prevented the inadvertent choosing of specific individuals for particular trial orders. One at a time the participants came to the start marked by a tethered red buoy and were briefed on their run. I held the stern of each boat whilst the recorder ensured that the correct trials were given to each individual in the right order. Participant trial orders are shown in Appendix 2.2. All those taking part were shown the line which they were to sprint down and told they must do so as fast as possible. An area where they could stop sprinting was highlighted which was beyond the actual finish. They were not shown the fixed end point. For all trials the participants were shown a fixed point on the horizon in front of them and informed they must look at that point for the duration of their run. This was emphasised strongly to them and they were told they would be asked after each trial whether they had done this. Figure 5a (p.224) provides a schematic diagram of the testing area layout.

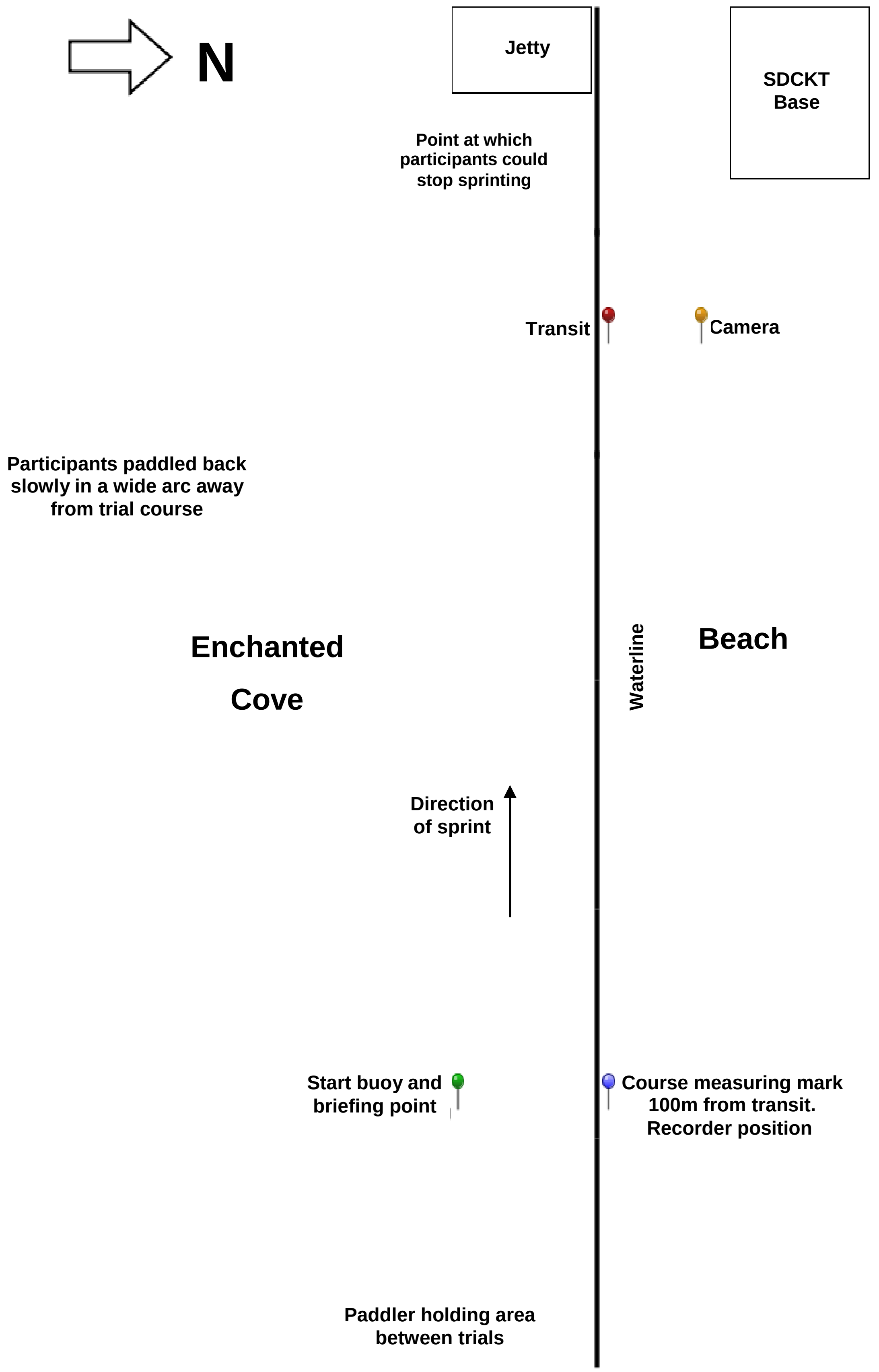

Figure 5a Schematic diagram showing venue layout and organisation

In the **control** condition no information other than the visual point was provided. Participants were asked to “*Look at the point identified*”. Whilst it was not stated, they were free to consciously consider anything they chose on this run. In the **proximal** condition participants were asked and required to concentrate all their conscious thoughts and mental effort on their boat stability and to not allow anything else to enter their mind. This instruction was condensed and emphasised as “*Think about the boat as requested*”. As in the control trial the paddlers were also asked to “*Look at the point identified*” to separate visual attention from conscious attention. Again, it was explained that this would be checked afterwards and that it was imperative that they make every effort to follow the instruction. The control of boat trim fore to aft (‘bobbing’) is often focused on by coaches in sprint kayak training as such movement is deemed by some to retard progress (e.g. Campbell, 2006, p.213). In the **distal** condition, as well as the visual point, participants had to focus all their conscious thoughts on the finish (being at the finish, finishing). No actual finish line was identified to those taking part nor was one visible to them. This, together with the visual point provided, operated to control vision and separate it from conscious focus. In this trial the two instructions constituted, “*Think about the finish as requested*” and “*Look at the point identified*”. The same admonishments were applied as before.

The same emphasis was applied in each case that the required conscious focus and visual reference should be maintained and that the paddler should sprint as quickly as possible. Once the instructions had been repeated back to me, were fully understood and it was clear that they would indeed be adhered to, the individual was allowed to start in their own time – no external countdown was provided. After each run participants paddled gently back around to the start away from other participants and waited for their next run. This allowed physical recovery and time for mental disengagement from the task. Following each evening's session all the participants were thanked for their time and reminded to not discuss their experience or the trials with anyone until they were all complete.

5.5.1 Measurement and recording

With the exception of heart rate monitoring and back-up hand timing, which were not used in this particular study, the measurement and recording methods employed were identical to those utilised in Study 1 (Section 4.5.1).

5.6 Results and analysis

The within-participants design, searching for a main effect of conscious attentional focus (independent variable) on performance time (dependent variable), indicated the use of a one way, repeated measures, analysis of variance (ANOVA). This was conducted using the PASW statistical software and produced both descriptive and inferential output. This software was also used to generate statistics to check whether some of the key variables had been controlled as intended.

The secondary, qualitative data collected from the participants were analysed using a basic content analysis. The statistical methods used in this study are the same as in Study 1 and are as explained in Chapter 4, section 4.6. A more in-depth justification of the analytical approach deployed can be found in the Research Methodology (Chapter 3, section 3.6).

5.6.1 Descriptive statistics

Table 5.1 indicates that the control condition, in which no conscious focal point was provided, has resulted in the fastest performance times. The distal condition was fractionally slower (0.07 seconds) whilst the proximal condition produced a clearly slower mean performance speed than the control (1.07 seconds). The range of times, as indicated by the standard deviation figures, was consistent across all conditions. See Appendix 2.6 for the data table.

Table 5.1 Performance times, standard deviations and standard errors.

Condition	Mean (Seconds)	Std. Deviation	Std. Error	Number
Control	28.96	3.07	0.77	16
Proximal	29.83	3.14	0.79	16
Distal	29.03	3.32	0.83	16

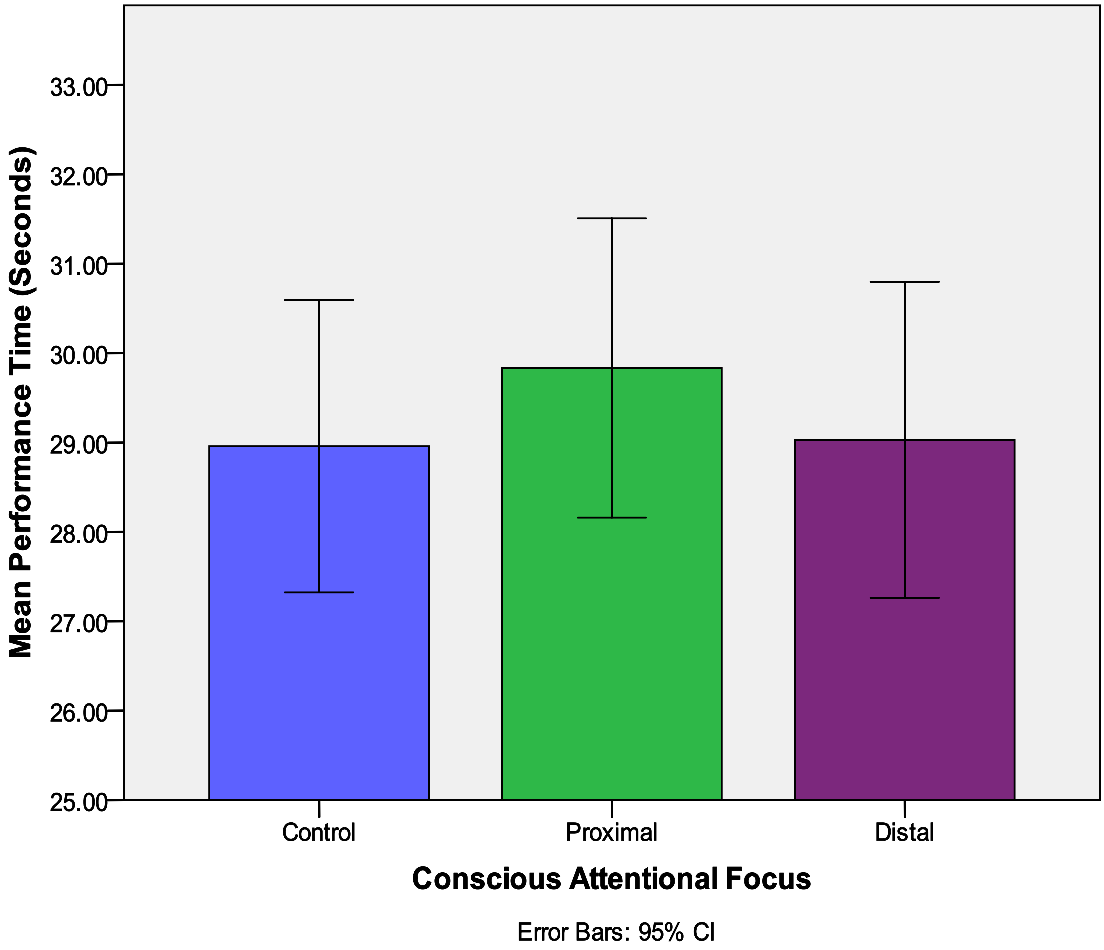

Figure 5b Mean performance time related to attentional focus

Figure 5b provides a visual representation of the relative mean times per condition with the 95% confidence interval error bars. Note that the *y* axis scale begins at 25 seconds so as to provide clarity.

5.6.2 Inferential statistics

Mauchly's test indicated that the assumption of sphericity had been met, $\chi^2(2) = 5.16$, $p > .05$, therefore degrees of freedom required no correction. The results show that conscious attentional focus had a significant effect on the speed of kayaking performance, $F\ (2.0, 30.0) = 4.49$, $p = .02$, $\eta_p^2 = .23$

The overall effect magnitude reported above (η_p^2 = .23) represents a large effect as explained by Harris (2008). An effect size greater than .14 is deemed to be large; the reported effect above indicates that 23% of the variance in the dependent variable can be accounted for by the impact of the independent manipulation. The effect of conscious attentional focus on performance time in this experiment was therefore both significant and considerable.

Table 5.2. Pairwise comparisons

(I) focus	(J) focus	Mean difference (I-J)	Standard Error	Sig.[a]
Control	Proximal	-.88*	.29	.028
	Distal	-.07*	.26	1.00
Proximal	Control	.88*	.29	.028
	Distal	.81*	.40	.194
Distal	Control	.07*	.26	1.00
	Proximal	-.81*	.40	.194

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
a. Adjustment for multiple comparisons: Bonferroni.

Bonferroni *post hoc* tests revealed a significant difference in sprint kayak performance times only between the control and proximal conditions, CI .95 = -1.67 (lower), -.087 (upper), p = .03. No other comparisons were significant (p > .05 in all remaining cases).

5.7 Qualitative statistics

The self-scores, preferences and feedback from each participant were collated and are presented below.

5.7.1 Self-scores

At the end of each trial run participants were asked to provide a self-score between 0 and 100 based on their view of their own performance (100 being best). They were informed that they could use the score from their first trial (pre-test) as a benchmark around which they could provide scores in later runs. This gave a clear indication of how they believed each performance compared and therefore the perceived impact each condition had. The descriptive analysis is below. The full data set can be found in Appendix 2.6.

Table 5.3 Descriptive statistics for sprint kayaker self-scores

	Number	Minimum	Maximum	Mean	Std. Deviation
Control	16	50.00	97.00	78.69	17.14
Proximal	16	51.00	98.00	80.84	11.63
Distal	16	49.00	97.00	83.00	13.90

Table 5.3 suggests that the participants believed that the distal condition was the most effective in relation to performance speed and that the control trial was the slowest. This is not borne out by the actual times and suggests that

performers are not capable of identifying which conditions are most beneficial to them – especially when the differences are relatively small.

5.7.2 Participant preferred condition

At the end of their participation, each volunteer was asked to place the three conditions into a rank order and to provide reasons why. They scored each either 1 (most preferred), 2 or 3 (least preferred). Table 5.4 shows the summary data. The full data set can be found in Appendix 2.6.

Table 5.4 Descriptive statistics for sprint kayaker condition preferences

	Number	Minimum Score	Maximum Score	Modal Score (number)	Mean	Std. Deviation
Control	16	1.00	3.00	3 (7)	2.19	0.83
Proximal	16	1.00	3.00	3 (7)	2.13	0.89
Distal	16	1.00	3.00	1,2 (7)	1.69	0.70

Table 5.4 shows that the control condition was the least preferred by the participants using a mean score, though both the control and proximal trials were listed as the least favoured on seven occasions. The distal condition was the one most preferred. This paradoxical result does not correlate with the actual, timed performance data and indicates that participants may find it difficult to accurately identify critical factors within their performance when deciding which to favour.

5.7.3 Participant comments on trial conditions

Participant comments were collected at the end of each trial run in regard to their performance and how they thought the condition affected them. A basic content analysis was conducted whereby similar comments were categorised and the total in each category added. The summary data is provided below, example comments and the full analysis can be found in Appendix 2.7.

Table 5.5 Positive and negative comments on each trial condition

Condition	Positive Comments	Negative Comments
Control	8	5
Proximal	19	10
Distal	15	6

Table 5.5 suggests that the proximal condition was the most favoured as well as drawing the most adverse remarks. The balance of comments in both the proximal and distal conditions is predominantly positive. Feedback on the control condition was both of a lower volume and more evenly distributed. The volume of negative comments was similar across the control and distal trials though greater in the proximal condition.

The pairwise comparisons (Table 5.2) demonstrated the only significant difference to be between the control and proximal conditions – with the control trials outperforming those under the proximal focus. Table 5.5 shows no correlation between participant preferences and the timed performance data. This may demonstrate that participants find it difficult to discern the type of training conditions which are most effective for them. It also provides reassurance that no participant effects (Halo, Hawthorne etc.) impacted on the study.

5.8 Discussion

The results of this study demonstrate that conscious attentional focus had a significant effect (p = .02) on the performance of K1 kayak sprinting speed. The size of the effect was also large (η_p^2 = .23). Pairwise comparisons show that the only significant difference lay between the no-focus control condition and the proximal trial – the fastest and slowest respectively. The mean time for the distal condition was marginally slower than the control run (0.07 seconds) though did not meet the .05 criteria for significance over the proximal focus. To my knowledge, this is the first study to evaluate the impact of attentional focus in sprint kayaking (K1). The present study builds on the findings from Study 1 (Chapter 4) by using a highly competitive Olympic discipline with youth racers as participants. As with Study 1 in this thesis, the current work also assesses conscious focus effects in a continuous skill and, to augment that work, again utilises a discipline which requires the participants to propel a large and challenging piece of equipment.

This study's findings are unusual and do not concur with the majority of attentional focus research (Shea and Wulf, 1999; McNevin *et al*., 2003; Lohse *et* *al*., 2010; Wulf, 2013), on the contrary, such research typically demonstrates an external focus benefit whilst the internal and control conditions are not significantly distinguishable. Whilst there was no internal focus trial in the present study there were two external focal points, both of which produced inferior performances to the no-focus control condition. A central tenet of this study was to investigate the distance of external focus in order to better understand the relative merits of points closer or further from a performer. Unlike in Study 1 (Chapter 4), which resulted in both a significant distal focus benefit and a proximal focus detriment relative to the control (no-focus) condition, in the present work there was no significant difference between the two external focal points. This is not consistent with the small number of previous studies which have examined distance of conscious focus (e.g. McNevin *et al*., 2003; Bell and Hardy, 2009; McKay and Wulf, 2012; Porter *et al*., 2012) though this area of enquiry is still in its 'infancy' and inconsistency between studies which may have different structures and content is to be expected. In the current study there were indeed several aspects which were novel or uncommon (i.e. type of participant, sporting domain, equipment type, skill type, focal points and methodology) any one of which may account for the results reported.

The findings of the current research suggest that in a technical discipline such as sprint kayaking, in which the ability to reproduce an efficient movement pattern with a high degree of consistency is critical, athletes, once they achieve this, are able to self-select an optimal focus point which cannot easily be surpassed. An alternative, or perhaps additional, explanation may be that age interacts with attentional focus benefits: in the case of the present study the youth of the participants may be an important factor perhaps due to their stage of physical and/or cognitive development. Without conducting further studies to properly compare any potential age and developmental effects it is not possible to reach a conclusion on this factor from the present study alone. Other research which has evaluated the impact of attentional focus on children and youths may though, provide some guidance. The small amount of research conducted to date suggests that children benefit from an external focus in the same ways as do adults. This has been indirectly demonstrated with infants (Claxton *et al*., 2012), and directly in fit and healthy 10 – 12 year olds in both balance tasks (Thorn, 2006) and an applied football study (Wulf *et al*., 2010b). Developmental issues and attention deficit problems in young people (Chiviacowsky *et al*., 2013; Saemi *et al*., 2012 respectively) have likewise not been shown to alter the focus benefits repeatedly found in other groups. From this evidence it would seem that youth alone does not interact with conscious focus effects in any way that is different to other populations.

The issue of learning and training experience may be more informative: Maurer and Munzert (2013) examined the effect of focus on 14-18 year-old German national squad basketball players in a free throw task. They found that the participants performed more effectively when allowed to use their favoured focus – which was dominated by an internal preference. It transpired that the focus typically coached to the players was indeed an internal one, as has been found to be common across disciplines (e.g. Porter *et al*., 2010a; Campbell, 2006), and that they had therefore become adept at shooting with such a focus as well as, understandably, then favouring that approach. The coaching method utilised by the SDCKT coaches did appear to depend heavily on internal and proximal focus points for the sprinters; this personal observation was reinforced by the comments of some participants who reported a focus on technique as being common in their training. If the participants in the current study relied on their favoured and well practised focus during the control trial it seems possible this may have allowed them to perform at a higher standard than when they were directed to use an unfamiliar, restricted and fixed conscious focus.

Whilst this prior experience may go some way to explaining why the control condition was dominant in the present research, there were some important differences between the two studies. In Maurer and Munzert's (2013) work, favoured focal points were identified in advance of the tests so that participants could select exactly what they were going to concentrate on. This meant that, not only did the players select personalised rather than the same points, their performance may have been pre-empted by expectations of focus efficacy. In the present study, no prior assessment was made of the participants' preferred focus so as to avoid influencing them. On questioning them after each run it is interesting to note that the sprint kayaking participants actually reported the highest self-scores in the distal condition and the lowest in the control trial (Table 5.3). This was reinforced by their stated preferences which showed clear favour for the distal trial with the no-focus control condition being least preferred - though only slightly less liked than the proximal run (Table 5.4).

These findings suggest that the participants may well prefer a structured and directed focus and dislike conditions in which they have no guidance or are free to make their own selections. Whilst this may have led them to revert to their coached, and perhaps default, focus in the control run, the fact that it was the least favoured and received the lowest self-scores undermines the argument that prior experience of internal and proximal coached focuses was pivotal. The participants' self assessment and beliefs on their performance also indicate that it is very difficult for athletes to identify the most effective circumstances for them to excel; this finding matches that of Study 1 (Chapter 4) in which qualitative measures did not correspond with objectively timed performance data. As has been highlighted by academics over the last decade (e.g. Coffield *et al*., 2004a; Pashler *et al*., 2009; Geake, 2007; Reiner and Willingham, 2010), the beliefs and preferences of individual performers cannot be relied upon as a guide to the most effective conditions for them to acquire or retain skills.

Further to the above, it should be noted that asking the participants questions about their performance after each trial in the current study produced incomplete responses. Many of the young sprinters seemed unused to being asked to reflect on their own performance and many were unable or unwilling to comment in more than a perfunctory manner. For example, the participants were asked what they had focused on during the control trials; none provided an answer. Only eight provided an answer on their focus during racing and training therefore no table was provided on this in the results section. Fortunately, they were sufficiently forthcoming on their preference of trial and in the provision of self-scores so as to provide more comprehensive and useful feedback. Whilst many of the participants were relaxed and obliging when questioned, an approximately equal number were more reserved – this tended to be the female and younger kayakers. This could have been as a function of being removed from their normal training environment and having to work with someone whom they did not know and therefore did not feel confident to divulge their thoughts to. It may also be the case that they are unused to having to consider the questions asked. A further reason might be that in being tested in groups they felt self-conscious in front of their peers – even though they were questioned apart from the other paddlers. Whatever the actual explanation for the reticence experienced in the current work, future studies with young participants will need to consider experimental design and information gathering methods carefully.

The only prior attentional focus study to report a control (no-focus) trial benefit was Wulf's (2008) balance research with the *Cirque du Soleil* acrobats in Las Vegas. In that work, the expert acrobats performed significantly better in a balance task when using the control condition in which they were free to select their own focus. Wulf concluded that the participants had reached a level of optimal activity which could not be exceeded with a directed focus. In fact, it was also possible that the prescribed internal and external points acted to constrain the well established, subliminal control which the performers had developed, as has been claimed by Beilock and Carr (2001). As noted earlier (Chapter 2, section 2.8.1) the acrobats were not questioned on what they considered during the control trial though, as can be seen with the current study, the answers to such questions do not necessarily elicit an explanation for the results. What is apparent is that the high standard K1 sprinters in the present study seem to have produced a similar result to Wulf's (2008) research though, as discussed above, the reason for this is elusive.

A further issue worth mentioning is that in the present study the participants had to consciously attend to a non-visible finish. Whilst this may seem more challenging than concentrating on a 'concrete' object such as the boat, it is not something which sprint kayakers are unused to. In competitive sprinting a transit is also used and, though the transit points are known and visible, there is no physical or visible finish line on the water. For this reason racers cannot assume they know or can judge precisely where it is and therefore have to sprint beyond the area of the finish to be sure they have crossed it at maximum speed. This then is a very similar circumstance to the one created in the present study and therefore should not have disadvantaged those taking part. The feedback gleaned from the participants after the testing indicated that it may be common in their K1 training for a focus on the body, boat and paddle to be encouraged and used (though there were only eight responses to this question). This also demonstrates that the proximal focus used was one which is normal for K1 racers at SDCKT and therefore should not have hindered them. When future studies into the effects of focus distance are conducted, the difficulty of establishing comparable conscious focal points seems likely to recur, particularly as the distance between the internal, proximal and distal focuses increases. In the current study though, it seems that the points used were not abnormal for the participants and were not so different that they could cause the atypical findings recorded. Furthermore, it is important to note that the quantity of information that the participants had to contend with in each trial was kept to an absolute minimum and was unambiguous and distinct. No participants reported having any difficulty understanding or using the instructions.

An additional possible explanation for the unusual results lays, perhaps, with the participants themselves and the way in which they were enrolled into the study and then took part in small groups. Whilst it was made very clear to each individual that they were under no pressure to take part if they did not want to, the fact they were directed to attend by Chris Barlow (the SDCKT head coach) meant they were less likely to believe they actually had a real choice. This may then have produced a participant group of 'pressed men' rather than true volunteers, which means that their motivation to take part may have been variable. The reluctance of several of the participants to provide information about their performances, as discussed earlier, did lead to concerns over enthusiasm and levels of effort, though neither of these factors were measured. A further issue which may have impacted on the participants' willingness to put maximum effort into the tests was the fact they were missing out on the training which they had arrived to take part in that evening.

In addition to the concerns above, the structure of each evening's testing session meant that three or four participants were rotated through the protocols at the same time which may have impacted on any individual accountability or pressure to perform to the best of their ability. In effect, as social psychologists have highlighted in many situations (e.g. Bandura, 1999; Thornberg *et al*., 2012) participating as part of a group may have led to a diffusion of personal responsibility. When the differences in times are relatively small any such variation in effort on the part of participants could have a significant impact on the outcomes. Whilst there is no way to know if these issues actually manifested themselves in the performances of those taking part, and the within-participants design did offer protection against variable effort between participants, future studies to verify the current findings might be valuable. It would also seem wise in future experiments to take great care when dealing with participants who are not true volunteers, and to work with individuals in isolation whenever possible to mitigate the concerns above.

The measurement of peak heart rate which was applied in the previous study (Chapter 4) was not used in the current work. This was not because it was deemed unnecessary to determine effort, recovery and to act as a distraction from the study's true purpose, rather it was due to practical limitations as explained in Section 5.4.4. Whilst such monitoring has not been commonly used in attentional focus research, possibly because there have been few other activities studied which aerobically challenged the participants (Hessler and Amazeen, 2009 and Schücker *et al*., 2009 being exceptions), it was found to be more informative and useful in Study 1 than had been foreseen. In hindsight, measuring peak heart rate in the current study would have potentially provided useful information on the level of effort expended in each of the trial conditions which may have helped understand the unusual findings. Future studies of aerobic activities should consider such physiological measures when possible, to assist in understanding the interaction between heart rate, effort and attentional focus as well as to check that such effort is consistently applied in all conditions. The restriction in this study caused by lack of equipment could have been overcome if it had been possible to work with a single participant at any one time rather than rotating a group through the protocols.

As in the surf ski based research (Study 1), the current work utilised a large and challenging piece of apparatus to which the participants were conjoined, this work represents only the second attentional focus experiment to use such an activity. Whilst in the present research (Study 2) no internal focus condition was used, the proximal trial produced results which were significantly slower than the no-focus control run (p = .028), and therefore akin to internal focus findings in some other work (e.g. Marchant *et al*., 2011). This would also have been an uncommon finding had it been an internal versus control comparison and, notwithstanding a similar proximal focus deficit in Study 1, this has not been recorded in any applied research prior to this thesis. The fact that this has now occurred in two completely separate but consecutive experiments reduces the chance of it being mere coincidence.

In Study 1, the hypothesis was advanced that in situations in which the performer and their equipment could be considered a single entity, i.e. activities in which the athlete is attached to apparatus which they propel, such as in paddle-sports and cycling, then perhaps a proximal focus on the equipment, or certain aspects of the equipment, acts in the same manner as an internal focus on the body, i.e. the equipment becomes an extension of the body rather than a separate object. If this is the case, and further work will need to be conducted to establish this, then understanding the point at which this overlap takes place will be of value to coaches and learners alike. In other attentional focus studies in which equipment has been used, a focus on the body (internal) and a focus on the equipment (external, proximal) have typically resulted in an external focus benefit even though the two points have tended to be adjacent. For example, in studies in which equipment was thrown or struck by the participants e.g. basketball free throws (Al Abood *et al*., 2002; Zachry *et al*., 2005), discus (Zarghami *et al*., 2012), darts (Lohse *et al*., 2010) and volleyball serving (Wulf *et al*., 2002) an external focus was always found to enhance performance and/or retention relative to both an internal focus and a no-focus condition. Research in which the activity required the use of an implement to control or strike a further object, such as in the many golf studies conducted, has also consistently demonstrated an external focus (on the equipment) as being superior to an internal focus on the body and/or a no-focus control (e.g. Wulf *et al.*, 1999; Wulf and Su, 2007; Bell and Hardy, 2009; An *et al*., 2013).

If the concept of an internal-proximal focus intersection is correct, then it would appear that the equipment in use needs to move beyond being a mere implement to be wielded and become, instead, apparatus which is so fitted to the performer that the two move and interact in unison in a synthesised manner. At what point this may occur will require investigation, though canoe-sport appears likely to offer an effective 'testing ground'. In studies 1 and 2 the proximal focus on the boat may, arguably, have had the effect postulated and this might account for the significantly inferior speeds in this trial relative to the control condition. It is also possible, when using large equipment, to vary the proximal focus quite significantly in the search for attentional differences. Such a varied proximal focus testing regime may help refine knowledge and understanding as it cannot be assumed that a focus on one aspect of the equipment will produce the same attentional effects as the use of an alternative point. In kayaking, for instance, proximal points could be inside the craft on the foot pegs or outside on the paddle - as well on the boat itself as was used in the current and previous work. In this example the boat could be viewed as integral with the paddler whereas the paddle appears to be an implement. It may also be interesting to examine activities in which the equipment is smaller but no less conjoined: skiing, for example, may provide an interesting medium to study this phenomenon. If it does transpire that a, supposedly, external (proximal) focus is acting in the same manner as an internal one then this would help explain the performance decrements being seen in the current and previous studies, though it is still unusual for the no-focus trial to significantly outperform an internal focus (an example of this being Marchant *et al*., 2011). The explanations previously highlighted, i.e. that either a distal focus is being self-selected in the control trial or the participants have such an effective and well practised personal focus that it cannot be superseded (at least in the span of the experiments so far conducted) seem the most likely.

The present research is one of only a small number of projects to examine conscious attentional focus effects in a continuous skill: Stoate and Wulf, (2011) and Freudenheim *et al*., (2010) assessed focus effects in swimming whilst Ille *et al*, (2013) worked with track sprinters. Schücker *et al*. (2009) also used a continuous activity though their work used a running task on a treadmill in a physiology laboratory. In all cases an external focus was found to be beneficial relative to both internal focus points and no-focus control conditions. The fact that the above research has found no difference in attentional benefits in continuous skills compared to the, more common, discrete skill studies, indicates the use of a continuous skill in the current work is unlikely to have been a factor in the unusual findings. Interestingly, in Stoate and Wulf's (2011) study of expert swimmers, whilst there was a significant external (proximal) focus benefit in relation to an internal focus, the no-focus condition produced similar performance times to the externally focused trials. The researchers argued that this may demonstrate an internal focus should be avoided and, for experts, an external focus may be superfluous. Questioning of the participants after their swims revealed that during the control trials approximately half of those who had taken part had self-selected an external focus and it was these individuals who had performed as well under the control condition as in the external trial.

Had the same phenomenon as reported by Stoate and Wulf (2011) occurred in the current work, i.e. the sprint kayak racers had chosen an external (distal) focus in the no-focus condition, particularly if it was one they were familiar with, then this could explain how that trial produced times on a par with the directed distal focus. If the internal-proximal relationship that is advanced above proves to be correct, it would further justify my proposed explanation of the significantly slower times seen under the proximal condition. Whilst the responses gleaned from the participants on what they had focused on during the control trial were incomplete as previously explained, of the eight that did volunteer information, seven reported that they used a focus on technique during racing – all bar one of those actually used the term 'technique'. This rather undermines the notion that they may have self-selected a distal focus during the no-focus sprint, though their preference for the distal condition may indicate that their self-analysis of what they actually focus on is inaccurate. Future research will need to better harvest comments from participants on their control trial focus choices. The use of a structured questionnaire may be of more use with individuals who may be reticent. The lack of consistent participant self-reflection on their performances has made it more difficult to draw conclusions in the current study though, of course, even comprehensive subjective reporting may be inaccurate and misleading.

From a theoretical viewpoint, it is difficult to fit these findings into a currently available hypothesis. The Constrained Action Hypothesis (Wulf *et al.*, 2001; Wulf and Lewthwaite, 2010) would predict that both external focus conditions would produce superior performance to the no-focus trial. Not only did this not occur for either external point, the proximal focus conferred a disadvantage relative to the control condition. If the postulated overlap between internal and proximal effects in certain equipment (such as K1s) is correct, that would go some way to explaining these outcomes using this theory, though the lack of any external focus benefit does suggest there are limitations or exceptions to the Constrained Action Hypothesis. Willingham's (1998) COBALT neuropsychological theory of motor learning does, perhaps, offer a better explanation, particularly if the internal-proximal intersection proves correct. This model would envisage an internal focus disadvantage relative to a control condition, whereas it does not anticipate an external focus benefit. Theories of working memory overload (as explained by De Caro and Beilock, 2010) seem unlikely to have played any role in these findings: the participants were experienced performers with excellent subconsciously controlled skills, the additional information they had to attend to in the directed focus trials was task relevant and very limited. It therefore seems improbable that working memory capacity would have caused a performance detriment. As has been highlighted throughout this discussion, repeat studies need to be conducted to verify or challenge the findings in the present work so that more effective explanations may be provided for them.

5.8.1 Summary

This study has found atypical attentional effects in an applied, continuous, closed skill working with youth racers. The outcome that a no-focus control condition significantly outperformed an external (proximal) focus trial is unusual for any population so far evaluated (see Wulf 2013, p.80-82 and p.85-86). The fact that the distal (external) focus trial did not produce significantly faster times than either of the other conditions was also unexpected. The potential explanations for these effects have been debated above, though on the basis of a single study, the answers are still elusive. What does seem important is that further work will need to be conducted to verify or challenge these outcomes. The methodological issues highlighted by this study should also be borne in mind when designing future research.

Notwithstanding the unusual outcome and lack of a definitive explanation, this is a unique study in several ways and, as such, contributes to the current body of knowledge. The use of a large and challenging piece of apparatus in attentional focus studies has not been attempted by any other researchers. The finding in the current and previous studies that a no-focus condition outperformed the proximal external trial has led to the hypothesis that, in certain circumstances, a focus on aspects of equipment to which the performer is attached may lead to similar conscious attention effects with both internal and proximal focuses.

This then provides an interesting avenue for further study and could have significant consequences for performers and coaches.

The use of a continuous skill in a discipline not previously researched has further demonstrated the impact of attentional focus, albeit in an unexpected manner. In line with Wulf's (2008) *Cirque du Soleil* study, the performance of highly trained athletes was not enhanced with a directed focus – perhaps because they had already developed a well-practised or optimal focus which could not be surpassed in the short space of a study such as this or, as Stoate and Wulf (2011) posited, that an external focus may be superfluous in experts. It is also possible, as Beilock and Carr (2001) have reported, that when performers have an efficient technique or skill which is controlled at a subliminal level, requiring them to consciously consider a different and/or fixed focal point may be disruptive. If this is the case, it is interesting to note that only the proximal focus produced such a detrimental effect; the distal trial did not negatively affect the participants relative to their control trial speed. This then, may add weight to the evidence (e.g. Guillot *et al.*, 2013) that a distal focus may produce superior output once it becomes familiar to the performers. It would be interesting to run longitudinal research to assess if, given time, alternative focal points would begin to supersede the output of the one presently coached, used and favoured.

Working with young but highly trained athletes has added to the understanding of attentional effects on this population. Previous research findings (e.g. Thorn, 2006; Wulf *et al*. 2010b; Chiviakowsky *et al*., 2013) have consistently reported an external focus benefit for individuals of a variety of ages. Notwithstanding the methodological issues highlighted in regard to motivation and effort, there is no compelling evidence in the present work to suggest that age or stage of development resulted in different conscious focus effects to other populations studied. The alternative explanations posited for the findings in the current study appear more plausible and are better supported by other work.

The novel nature of this study demonstrates that it is quite possible to work in a fully applied context with a continuous skill and large equipment, thus making any findings more easily transferable to practise and coaching. As well as the obvious need to verify the current findings, with adjustments to the method as highlighted, there are also many other lines of enquiry which can be pursued. In particular, examining continuous skills in an open skill environment and over greater distances would be significant extensions to the body of research. Serial skills, such as slalom activities, would also be interesting to study to assess if switching focus during performance occurs and is beneficial. Examining different populations to verify that effects are global, as is believed (Wulf, 2013), or whether, indeed, they may vary under certain conditions. Cross-checking the current study's findings in sprint kayaking with other similar activities (e.g. cycling) may prove interesting and demonstrate the reliability or otherwise of the results. In particular, exploring the hypothesis that when conjoined to equipment which is propelled by the performer, that this may equalise the effects of an internal and proximal focus. This latter suggestion will need an internal focus to be included to provide the necessary comparison. Perhaps the natural extension of this work though, is to evaluate a continuous kayaking skill in an open skill environment using competent paddlers. The ensuing research (Chapter 6) seeks to address this issue.

In terms of the immediate impact of the findings from the present work, and as also found in the previous study (Chapter 4), the evidence suggests that a proximal focus on the boat is detrimental to sprint kayaking performance – the time differences observed could have a very significant impact on competitive placings. Coaches and performers should therefore review the focus encouraged in training and identify the one currently used by athletes when they are free to choose. They should also evaluate the potential benefits of a directed, distal focus. It may be the case that once performers have become used to such a focus, and it was preferred by the participants in the current research, that they may be able to further develop their sprinting speed.

Chapter 6

Study 3

6.1 Introduction

Following the two studies (Chapters 4 and 5) conducted in San Diego, California, examining attentional focus effects in an applied, recreational, closed skill setting (Study 1) as well as an applied, closed skill, competition context (Study 2), the original objective of investigating the effect of a proximal versus a distal focus in an applied open skill remained as an endeavour in waiting. The initial attempt to run such a study was thwarted by the difficulty of finding a suitably consistent environment and the demands of controlling potentially confounding variables. With the experience of having run two complete studies to draw upon, the challenges posed by such research were revisited.

Considering all possible sporting contexts, very few offer a skill which takes place in a variable environment as well as one in which that environment is sufficiently consistent to permit scientific comparisons to be made between trials and participants. As in studies 1 and 2, canoe-sports seemed to provide the solution as the variation and interference is provided, in the main, by the environment - and this can therefore be selected to afford both variety (openness) and consistency. Rather than the sea kayaking study initially proposed – with the variability being provided by sets of regular waves passing through the experimental area – this time the intention was to use static (and therefore more consistent) waves and other water features which the performers could travel through. Many rivers offer such conditions and, as the most accurate measure of performance available is time, choosing a paddle-sport activity which involved paddling quickly on rivers seemed appropriate. The two choices available were slalom and wild water racing.

Due to the radical direction and motor movement changes required in slalom, the complexity of this activity seemed better suited to a future stage of research. Wild water racing is concerned with travelling down river as quickly as possible whilst minimising any manoeuvres and following the line of least resistance. It is a continuous skill in which the predominant action required is forward paddling. It is far more realistic to have a finish focus which is the end point in this discipline, whereas in slalom each gate and turn in sequence seem likely to occupy the paddlers' focus. For these reasons wild water racing was selected for this study whilst slalom seems to offer the possibility of future work, perhaps evaluating intermediate and switching focal points.

6.2 Pilot

As with the boats used in the previous two studies, wild water racers are long, narrow boats designed to travel quickly in a straight line. This makes them less stable than many other craft therefore the exact choice of vessel was important to avoid either a floor or ceiling effect in terms of ease of use. McBee (2010) highlights the problems caused to statistical analysis when an insufficient range of measurement does not allow for effective differentiation between participants; such censoring may prevent the distinguishing of data sets at the upper or lower limits of an inadequate range and thereby lead to potentially biased results. Whilst McBee suggests an alternative analytical approach in such cases (the Tobit Model) it is clearly better to avoid such an occurrence at the outset. Several vessels were therefore piloted on both flat water and at the test venue to evaluate their characteristics, including a Pyranha Speeder, a Perception Wavehopper and an unnamed fibre glass wild water racing boat; this demonstrated that using a normal form racing boat with no significant compromises to increase stability should be adequately, though not excessively, challenging for competent paddlers. Using a standard design racing boat would also make the results more relevant to users and racers in this discipline. See Appendix 3.1 (Figures 3a, 3b, 3c and 3d) for images of the boat used with further information.

The pilot testing also evaluated a number of potential sites for the trials (all of which were rivers in Cumbria, UK) and included stretches of the Rivers Eden, Eamont, Brathay, Kent, Leven, Rothay, Derwent, Lune and Greta. The critical issue was to identify a stretch of water with good access, low disturbance and which provided consistent challenge at a range of water levels that would be appropriate for the discipline and paddlers – this was far from straightforward and consumed many days and much consideration. Once a venue had been chosen (see Section 6.3.4) the testing of potential course lengths and protocols could take place. Appendix 3.1 (Figures 3b, 3c and 3d) shows the boat being used at the actual study venue on the River Kent.

During the trialling of boats and visiting of potential venues, an assessment of course length was also made. Study 1 used a 75m course with competent paddlers whilst Study 2 employed a 100m course with youth sprinters – both in very fast craft and both on placid water. Basing the new course distance on this experience and then factoring in the additional circumstances of a different form of racing kayak, experienced river kayakers as participants (though not in a wild water racer) and the fact that the sprint would now be downriver on moving water, 100m seemed to be an appropriate distance. This was borne out during practise sprints while testing the boats - 100m proving sufficiently, though not overly, testing and therefore likely to make apparent any differences which existed between the conditions.

6.3 Experimental design

6.3.1 Participants

Following the identification, via my personal contacts, of potential participants in north-west England, all were written to with a view to taking part in the study. This produced forty positive responses and eventually resulted in twenty eight paddlers from a range of paddle-sport backgrounds volunteering to take part in the trials. All were competent to paddle on Grade 2 white water or harder and were currently active paddlers. The age range was 14 to 58 years with a mean age of 41 years and a standard deviation of 13.1. Six of the participants were female, twenty two were male. Only one participant had significant prior experience of paddling wild water racers having been ranked 5th in the UK; the majority of the remainder had little or no familiarity with the boat or discipline based on the experience scores they provided immediately before testing. Excluding the formerly ranked, competitive paddler, who scored 9, the mean score for the remaining 26 participants was 0.81 (standard deviation 1.39) on a scale with 0 as ‘no experience’ and 10 as ‘currently active and expert competitor’.

6.3.2 Ethics

Before commencing, checks were made to ensure that each participant was indeed sufficiently competent to manage the standard of water being used for the experiments. They were questioned on their prior paddle-sport experience in terms of quantity, quality and currency and, in particular, were required to provide reassurance that they were competent to navigate down the Grade 2 water provided by the study location.

On arrival at the venue each participant was provided with the Participant Briefing which explained the character and structure of the testing and its voluntary nature (Appendix 3.2). All participants were shown the area in which they would be asked to work and the equipment they would be required to use before the trials commenced. It was made clear to everyone that they could withdraw at any point for any reason and that they were under no pressure to continue if they did not wish to. No indication of the research field was provided at any time and the need for confidentiality was impressed upon those taking part to prevent contaminating future performances of other individuals. Participants were reassured that they would remain anonymous and their permission was sought to record their performance on video, on paper and via a heart rate monitor. Each volunteer was also required to complete an informed consent form and to provide emergency contact details and any medical or other information which may affect their involvement (Appendix 3.3). In the case of the single participant under 18 years of age, a parent provided the consent and also remained close by (though out of sight) during the testing.

6.3.3 Equipment

A Perception Wavehopper wild water racing kayak was acquired for the duration of the study (See Appendix 3.1, Figure 3a). The Wavehopper is constructed from polyethylene; this material is more durable than the fibre glass or carbon alternatives and therefore less prone to damage which could disrupt the experiment. The boat had suitable buoyancy in place and had footrest and backrest adjustment to enable fitting to individuals of a range of sizes. An SEL, carbon fibre, wing paddle was used for all participants as would be the norm for racing. All participants were provided with the same buoyancy aid (Kogg, 50Kn Centre Vest), which was of a vest design so as to not hamper the paddling action and adjustable so as to fit all users. In cases in which the provided buoyancy aid did not fit well then personal equipment was evaluated to ensure it would provide the same protection and freedom of movement as the supplied model. The spray deck (Reed Chillcheater keyhole deck) was also provided to ensure that it always fitted the boat’s cockpit and afforded the same feel and watertightness to all participants. All those taking part used their own paddling attire and footwear dependent on the conditions, though no-one was permitted to change their equipment or clothing part way through their tests. They were all advised that they should dress for high levels of exertion and should not wear clothing which might restrict their movements or cause them to overheat. All participants were required to bring and wear a suitable canoeing helmet – standardisation was not applied in this instance as fit is more important with this critical safety equipment. Spare helmets and clothing were always present in case anyone had inadvertently omitted to bring something.

Other experimental equipment consisted of exactly the same high speed video camera and tripod which was used in studies 1 and 2 (see Section 4.3.3), as well as a Polar FT1 heart rate monitor, comprising a transmitter attached via a chest strap and a data recorder in wristwatch form. The FT1 does not have a sampling rate as it does not download to any kind of file. Instead it displays heart rate in real time so updates it every beat and then displays maximums and averages when stopped. The data recorder was mounted on the shoulder strap of the buoyancy aid so as to be out of sight of the participants and to make it easily accessible for subsequent data collection. Participant information sheets were present so that they could be read out to all participants in advance. A clipboard and individual data sheets were produced to record all pertinent information during and after each of the trials (Appendix 3.4)

The start was marked by a mid-stream rock against which the stern of the boat was held at the start of each run. A 100 metre length of twine was used to measure the course to an identifiable finish point on the bank. This was then used for all runs. The finish (which was not visible to the participants) was provided by a transit across the course from the camera on one bank to this fixed point on the other. The camera was positioned on the opposite river bank to the one on which all the practical, experimental activity took place; this therefore reduced the potential distraction or impact of being filmed. No physical finish line was apparent or highlighted to those paddling in the trials. A waterproof mobile telephone was carried at all times to enable communication with the videographer as needed.

A general purpose kayak, kayak paddle and spray deck were positioned on the bank at the finish area so that assistance could be provided to anyone requiring it. This craft was also available to act as a support boat, for anyone wishing it, during the familiarisation period before testing. A dry suit, helmet and buoyancy aid were worn and a throw line was carried by me at all times – both to protect myself and also so that I could provide physical assistance if necessary. A first aid kit was always immediately available. The equipment remained consistent for all trials. I can be seen conducting an experiment in Appendix 3.1, Figure 3b.

6.3.4 Venue

A 30 metre wide, straight stretch of the River Kent in Kendal (Ordnance Survey grid reference SD 517 914) was used for the experiment. This provided public access via riverside park land over a 200 metre distance with a slipway into the river in the finish area. The bank on the side used was very low to the river permitting ease of access and egress along its entire length; the river banks on the opposite bank were higher with a wall running along the entire length effectively canalising the river. This provided an ideal vantage point for the video camera. The form of the river and its bank features were consistent along this stretch thus removing distracting or helpful features (Appendix 3.1, Figures 3b, 3c and 3d provide images of the venue in use during the trials). The River Kent is classified as Grade 2 at this point (Hayward, 1992; Miller, 2003) which is described in the British Canoe Union's Terms of Reference[28] (p.14) as: 'Moderate – small rapids featuring regular waves. Some manoeuvring required but easy to navigate'.

The 100 metre length of the venue used for the speed trials had moving water throughout its length with small recirculating waves and eddies to be negotiated by the paddlers. A clear 'best line' was apparent. The river conditions remained consistent across a range of depths and it was still paddleable even when no rain had fallen for many days. Due to the Kent's large catchment area sudden rain did not result in rapid water level changes meaning the only variable that could change quickly would be the weather. Within its normal range it was always possible for me to wade out into the river to hold the boat against the rock used as the start position and to brief participants on each of the trial requirements from that point (Appendix 3.1, Figure 3b). Whilst

[28] The British Canoe Union's Terms of Reference for Coaches and Leaders (2013, version 4.1) is only available as an online document. It can be found using the following website link: http://www.canoe-england.org.uk/media/pdf/BCU%20TERMS%20OF%20REFERENCE%20V4-1.pdf

access was via public land it was seldom frequented by other people: there were no other water users or anglers at any time.

6.3.5 Environmental hazards

Cold water and slippery rocks on the river bed provided a minor hazard. Occasional rubbish on the river bed provided an entanglement risk to anyone standing in the water though I was most at risk due to the need to wade out into the river to hold the boat at the start of every trial.

6.3.6 Staff

In addition to being responsible for the organisation, set up and safety of the study I also briefed all the participants and controlled the start of each trial. Data from the heart rate monitor were recorded after each trial as well as the participants' self-scores and comments on their performance and experience. This was also conducted by me. A professional photographer operated the video camera at all times.

6.4 Control of variables

Given the naturalistic format of the study there was the potential for a range of variables to confound the results, these were controlled or assessed as follows:

6.4.1 Trial Order

The distal, proximal and control conditions were counterbalanced and rotated through three (rather than all six) of the possible combinations. This 'Latin

Squares' approach was used to provide larger trial order sub-groups so that it would be easier to identify any ordering effects on performance (see Field and Hole, 2003, p.84 for a comprehensive explanation of this technique). These were listed in advance and the next participant to present themselves was placed in the subsequent combination so that pre-ordering could not inadvertently select certain individuals for certain trial orders. (Appendix 3.5 shows the trial order for each kayaker).

6.4.2 Training effect

The trial order counterbalancing had the additional benefit of allowing the identification of any training benefit from the first to the third run. However, due to the varied prior experience of the participants and the fact that only two scored more than 3 on the wild water racing prior experience scale (none had current experience in this type of boat), there was the potential for a training effect as they progressed through the trials. To combat this, each participant was briefed that they must warm up and familiarise themselves with the craft for sufficient time so that they felt that they had plateaued in terms of short term improvement, i.e. that they did not feel they would make any further improvement during the duration of the tests. They were asked to practise sprinting though not to use so much time and energy that they became fatigued. Both training and fatigue effects were explained to them and why they needed to be avoided. This meant that differing amounts of time were utilised by participants before their testing phase began. Furthermore, each participant was shown the course they would be asked to sprint down in advance of them getting on the water. They were asked to practise paddling down the course so that they could clearly identify the best line – a line they would use on each of their subsequent runs. Whilst they were provided with bank-based safety support during this period they were never permitted any coaching or guidance as this may have been something they later considered during the tests.

In addition to the above preparation, each participant had a pre-test as an additional run in advance of the experimental trials; this served several purposes. In regard to any potential training benefit it acted as a 'dress rehearsal' and real-time practise for subsequent runs thereby tackling any residual anxiety and sudden performance improvements later. The pre-test is explained more fully later (6.5).

6.4.3 Trial briefings

The trial briefing followed the same format as studies 1 and 2 (see Section 4.4.7). The instructions for each trial condition can be found in Appendix 3.6.

6.4.4 Vision

Vision was controlled in the same manner as in studies 1 and 2 (see Section 4.4.2) so that the visual point was consistent across all trials and only the conscious focus varied.

6.4.5 Modelling

Potential modelling was managed and avoided in the same manner as in Study 1 (Section 4.4.3).

6.4.6 Fatigue

As paddling a wild water racer and sprinting may have been activities which the participants did not take part in, there was a risk of accumulated fatigue during the trials affecting their performance. This could be exacerbated by any anxiety they felt in an unfamiliar boat – particularly if it was less stable then their usual craft – though it was not possible to measure anxiety or its effects. In addition to the activity familiarisation period a heart rate monitor was fitted to each participant so that their starting heart rate could be scrutinised and allowed to recover fully between runs. Peak heart rates were also recorded so that maximal effort was monitored - if this dropped consistently from the first to last run it may have indicated that the participant was tiring. This is, of course, an imprecise guide as other factors such as trial conditions, motivation, effort, anxiety etc. may also impact on peak heart rate.

6.4.7 Expectations

Participant expectations were controlled and monitored in the same way as in Study 1 (see Section 4.4.8)

6.4.8 Environmental conditions

Environmental conditions remained stable across all valid trials. The venue previously described provided a consistently varied location with fixed river features. There were two occasions when the conditions were not stable: on the first the test was rescheduled before the start due to very strong and gusting wind, on the second, bright, low, winter sunlight came out directly in front of the participant part way through their tests which then reflected from the water, seriously hampering visibility. The data from this trial had to be discarded and a further volunteer recruited.

6.4.9 Information sharing

All the participants were thoroughly briefed on the necessity to not discuss their experience with anyone else as this would potentially influence the performance of other individuals taking part in the trials, thereby compromising the data and results.

6.5 Method

As with Study 1 and Study 2 a within-participants design was deployed for the same reasons as explained in Section 4.6.

On meeting each volunteer, and following introductions, the Participant Briefing was provided to them to read (Appendix 3.2). It was emphasised that the choice to participate was theirs alone and that they could withdraw at any time. Once suitably attired the participants were shown the boat and equipment and helped to fit and adjust everything to their personal preference. This was done on a flat, grassy area rather than on the water. When duly equipped and ready, they were invited to follow any land based warm-up routine they wished and were then supported into the boat. All those taking part were shown the start, the stretch of river being used and the line which they were to sprint down as well as the area (beyond the actual finish) where they could stop paddling; they were informed they must paddle as fast as possible in all runs and that the intention was not to improve trial on trial but to sprint as fast as possible under the conditions provided. The participants were not shown the actual end point; no physical finish line was present or visible. At no point during the testing was it apparent that a participant had identified the actual finish.

The participants were encouraged to warm up in the boat to reach a level of comfort and familiarity so that they felt they would not make significant performance gains as a result of the testing regime. They were also asked to practise starting, sprinting and to identify their line down the course, again in order to remove potential training effects during the trials. However, they were asked to ensure that they did not exert themselves to the point where they would not be able to sprint to their full potential in all four runs. This period varied significantly across participants depending on prior experience and confidence in a wild water racer. The range was 10 to 30 minutes though this was not timed and recorded. Bank based safety was present at all times. No coaching was provided at any time.

Once a participant stated that they were ready, they were asked if they felt they would make significant, further performance gains by virtue of having four consecutive sprints. Clearly this is a subjective judgement which could be inaccurate. It was therefore necessary that I agreed with each participant's analysis before they could proceed to the pre-test. If, from my observation and analysis of their paddling during the familiarisation phase, I believed that they could still develop, I could prescribe further practise. Once agreement was reached the participant was supported off the water at the slipway in the finish area. The heart rate monitor, which had been worn from before getting on the water but not used for data gathering, was reset and the boat carried upriver to a point opposite the start. On every occasion the boat was returned to the start the participant would be engaged in a different conversation unrelated to the task at hand. This was to distract them from their immediate experience or from considering and preparing for the next trial.

The participants were assisted into the wild water racer so that they remained dry and did not introduce water into the boat. Every effort was made to maintain as much consistency between trials as possible. I then waded out to the starting point, positioned myself in the eddy downstream of the start rock and, when the participant arrived, held the stern of the boat against a notch in the rock (Appendix 3.1, Figure 3b). The starting heart rate was noted. Figure 6a (p.295) shows the venue layout.

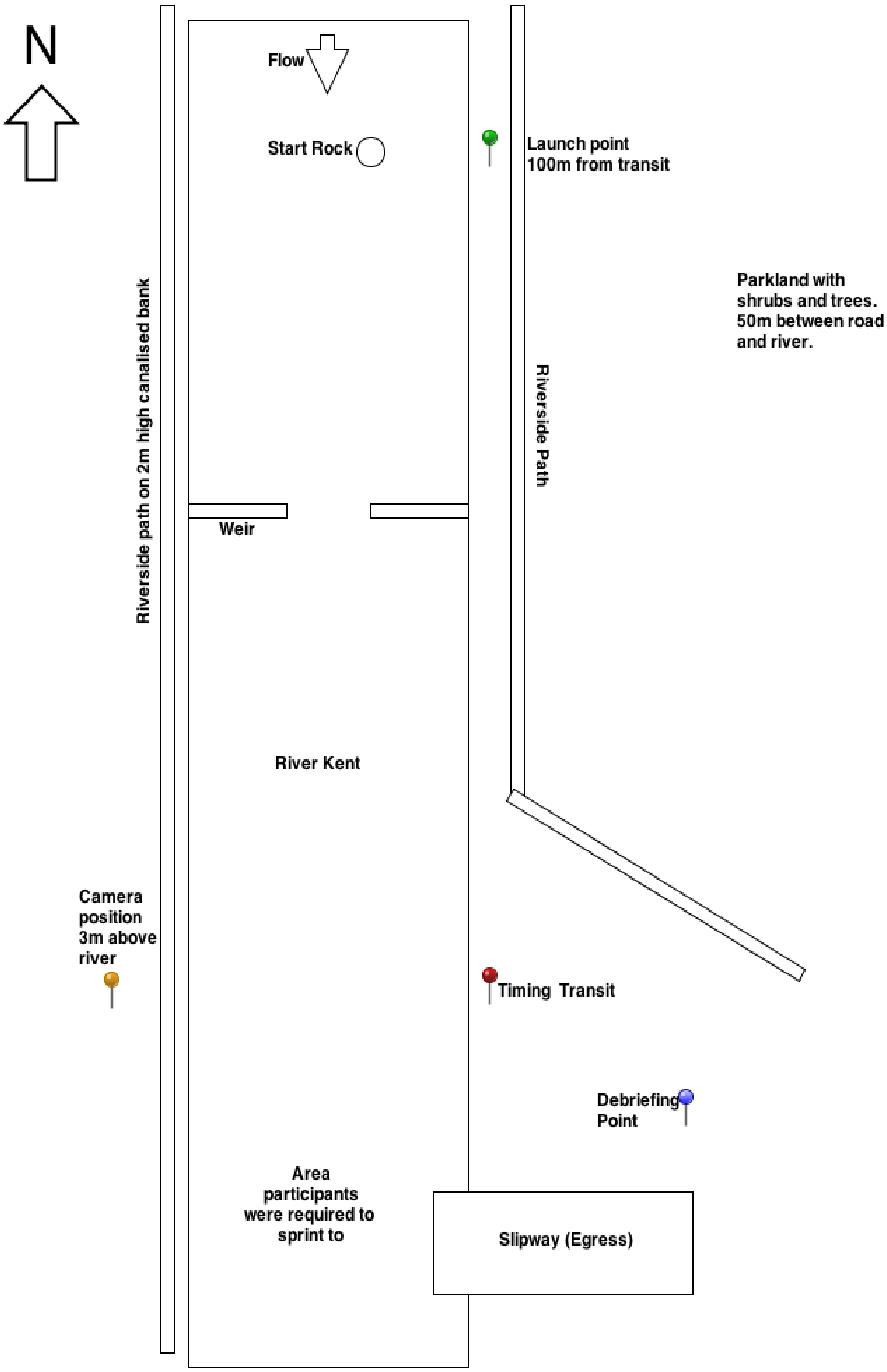

Figure 6a Schematic diagram of experimental venue and organisation

The pre-test was run first for all participants. Once at the start the instructions were read to them and their understanding was checked. They were required to paddle as fast as possible down the identified course. No visual or conscious focus was provided. This therefore constituted a completely normal wild water racing or training task as the participants had the freedom to focus on and look at whatever they chose. For the three subsequent experimental trials the participants were shown a fixed point well beyond the finish in front of them and informed that they must look at that point for the duration of their run. This was emphasised strongly and they were told that they would be asked after each trial whether they had done this. The same point was used on each trial for all the participants.

In the **control** condition no information other than the visual point was provided. Participants were asked to "*Look at the point identified*". Whilst it was not stated, they were free to consciously consider anything they chose on this run. In the **proximal** condition participants were asked and required to concentrate all their conscious thoughts and mental effort on their paddle and to not allow anything else to enter their mind. After the explanation the participant was asked to concentrate on their paddle throughout. This instruction was condensed and emphasised as "*Think about the paddle as requested*". As in the control trial the paddlers were also asked to "*Look at the point identified*" to separate visual attention from conscious attention. Again, it was explained that this would be checked afterwards and that it was imperative that they make every effort to follow the instruction. The paddle and paddling technique is commonly focused on by coaches in race training and is regarded as essential by coaches and participants alike (Ferrero (Ed.), 2006, Chapter 12).

In the **distal** condition, as well as the visual point, participants had to focus all their conscious thoughts on the finish (i.e. being at the finish, finishing). No actual finish line was identified to the kayakers nor was one visible to them. After the explanation they were asked to think of 'Finish' throughout the run. The instructions constituted, "*Think about the finish as requested*" and "*Look at the point identified*". The same emphasis that the required conscious focus and visual reference should be maintained and that the participant should sprint as quickly as possible was applied in each case. Once the instructions were read and fully understood, and it was clear that they would be adhered to, the participant was allowed to start in their own time. After each run they paddled gently back to the slipway beyond the finish and were assisted out of the boat so as to remain dry. Following each participant's session they were thanked for their time and reminded to not discuss their experience or the trials with anyone until they were all complete.

6.5.1 Measurement and recording

Measurement and recording protocols were the same as those used in Study 1 (see Section 4.5.1).

6.6 Results and analysis

The within-participants design used in this experiment to ascertain any significant impact of conscious attentional focus (independent variable) on performance time (dependent variable) requires that a one way, repeated measures, analysis of variance (ANOVA) be used to analyse the data. This was conducted using the PASW statistical package.

As well as being able to identify any main effects and inter-trial effects, it is also possible to use this technique to check the impact of any of the identified variables – to ensure that they were indeed controlled. Further analysis may detect different experimental impacts on sub-groups which could then provide avenues for future research. It should be noted however, that repeated analysis of sub-group data increases the probability of false-positive results and therefore it is not wise to make claims on this basis (Brookes *et al*., 2004). The secondary, qualitative data which were collected from the participants was examined using a basic content analysis.

The analysis used in this study matched that deployed in the previous two experiments and as explained more fully in Study 1 (Chapter 4, section 4.6). A more thorough justification of the statistical methods used is provided in the Methodology (Chapter 3, section 3.6).

6.6.1 Descriptive statistics

Table 6.1 indicates that the distal condition produced the fastest performance times. The control and proximal conditions were very similar with the proximal performances marginally slower. Figure 6b provides a visual representation of the mean performance times in seconds.

Table 6.1 Performance times, standard deviations and standard errors

Condition	Mean (seconds)	Std. deviation	Std. Error	Number
Control	31.96	3.58	0.81	27
Proximal	32.07	3.27	0.71	27
Distal	30.63	3.21	0.67	27

Participants' performance speed was measured to an accuracy of 0.04 seconds under the three experimental conditions. Table 6.1 shows that the distal condition was the most effective. The proximal and control conditions were very similar though the proximal focus run was the slowest. The full data table can be found in Appendix 3.7.

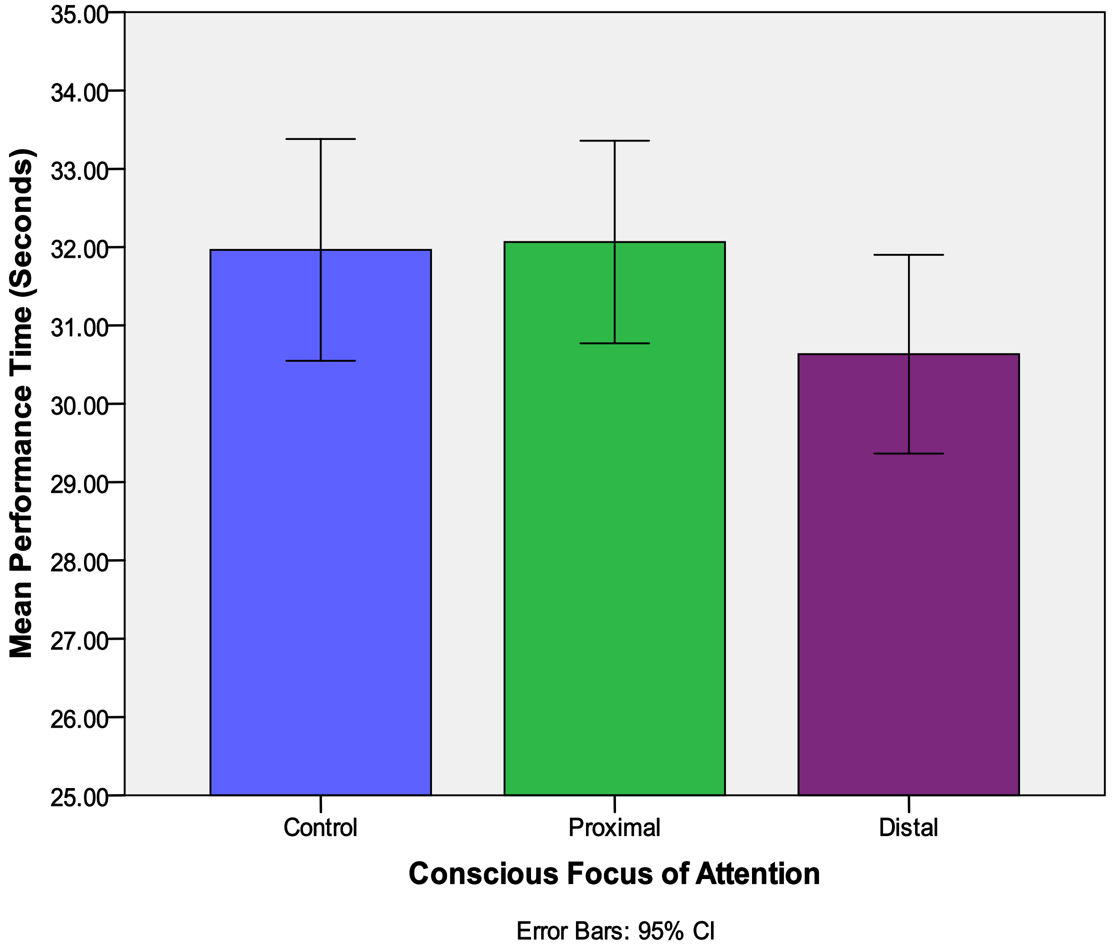

Figure 6b Performance times related to conscious focus condition

Figure 6b provides the confidence interval error bars as well as a visual representation of the difference between the trial means. Note that the origin on the *y* axis has been moved to 25 seconds to improve the clarity of the graph.

6.6.2 Inferential statistics

Mauchly's test indicated that the assumption of sphericity had been met, $\chi^2(2) = 2.75$, $p > .05$, therefore no correction of the degrees of freedom was required.

The results show that conscious attentional focus had a significant effect on the speed of kayaking performance in wild water racing. $F\,(2, 52) = 28.85$, $p < .001$, $\eta_p^2 = .53$

As Harris (2008) explains, the partial eta squared value reported above ($\eta_p^2 = .53$) represents a large effect. Using this measure an effect size greater than .14 is considered large; .53 means that 53% of the variance in the dependent variable can be attributed to the impact of the independent manipulation. The effect of conscious attentional focus on performance time in this experiment was therefore both highly significant and substantial.

Table 6.2. Pairwise comparisons

(I) focus	(J) focus	Mean difference (I-J)	Std. Error	Sig.[a]
Control	Proximal	-.10	.18	1.000
	Distal	1.33*	.24	< .001
Proximal	Control	.10	.18	1.000
	Distal	1.43*	.21	< .001
Distal	Control	-1.33*	.24	< .001
	Proximal	-1.43*	.21	< .001

Based on estimated marginal means
*. The mean difference is significant at the .05 level.
a. Adjustment for multiple comparisons: Bonferroni.

Bonferroni *post hoc* tests revealed a significant difference in wild water racer performance time between the distal and proximal conditions, CI .95 = -1.98 (lower), -0.89 (upper), $p < .001$ and the distal and control conditions CI .95 = -1.94 (lower), -0.72 (upper), $p < .001$. There was no significant difference between the proximal and control trials ($p = 1.00$).

This clarifies where the large effect found by the main analysis lies and indicates that performance speed is significantly enhanced under a distal focus.

6.7 Control of critical variables

As well as controlling for confounding variables, data were collected on critical factors so that a *post hoc* statistical check could ensure this had been effective.

6.7.1 Trial order

Trial order was counterbalanced using a 'Latin Squares' approach so as to protect against any effect being as a result of the order (see Field and Hole, 2003, p.84). The next participant to volunteer was always placed into the next available configuration; this avoided selection to enhance any desired outcome. There were nine participants in each trial order. Appendix 3.4 contains the participant characteristics and trial order information.

Table 6.3 Pairwise comparison of trial orders

(I) Trial Order	(J) Trial Order	Mean Difference (I – J)	Standard Error	Significance a
C.P.D	P.D.C	-2.07	1.55	.589
	D.C.P	-1.70	1.55	.862
P.D.C	C.P.D	2.07	1.55	.589
	D.C.P	.38	1.55	1.000
D.C.P	C.P.D	1.70	1.55	.862
	P.D.C	-.38	1.55	1.000

Based on estimated marginal means
a. Adjustment for multiple comparisons: Bonferroni.
C = Control, P = Proximal, D = Distal

Table 6.3 shows that there were no significant interactions between trial order and performance; $p > .05$ in all cases. This suggests that the counterbalancing method used was effective.

6.7.2 Exertion, fatigue and training benefit

Participant exertion was measured by comparing peak heart rates during each trial. This served to assess whether exertion was related to trial condition, or whether exertion diminished over the trials thus indicating that fatigue or decreasing motivation may be having an impact. It was also possible that if exertion was related to trial order in either an increasing or decreasing manner this could indicate a training benefit – in the first instance because participants could exert more effort as they became increasingly familiar with the activity or, they exerted less effort because they became more relaxed, efficient or tired with practise. The full heart rate data can be found in Appendix 3.7.

Table 6.4 (below) shows that, irrespective of trial order, peak heart rate (HR) was greater in the distal condition. The control condition demonstrated the second highest peak HR whilst the proximal trials had the lowest mean. The difference between the means for the distal and proximal conditions is 3.93 beats per minute. This data directly correlates with performance speed in that the participants' fastest runs coincided with their highest heart rates.

Table 6.4 Mean peak heart rate (HR) by trial condition and trial order

Condition	Position in trials	Mean (bpm*)	Standard deviation	Number
Peak HR Control (C)	**C**.P.D - 1st	169.1	10.97	9
	D.**C**.P - 2nd	164.8	12.11	9
	P.D.**C** - 3rd	162.2	19.77	9
	Total	165.4	14.52	27
Peak HR Proximal (P)	**P**.D.C - 1st	163.6	20.82	9
	C.**P**.D - 2nd	166.2	8.93	9
	D.C.**P** - 3rd	161.2	12.17	9
	Total	163.7	14.42	27
Peak HR Distal (D)	**D**.C.P - 1st	167.8	13.21	9
	P.**D**.C - 2nd	164.9	19.64	9
	C.P.**D** - 3rd	170.1	9.06	9
	Total	167.6	14.23	27

***beats per minute**

Table 6.5 (below) demonstrates that the differences in peak heart rate between conditions was significant between the distal focus and both others ($p < .05$) though not so between the control and proximal trials ($p > .05$). There appears to be a correlation between speed of performance and peak HR which suggests that trial order did not have an impact, there was no fatigue effect and there was no training effect.

Table 6.5 Pairwise comparison of peak heart rate by trial condition

(I) Peak HR	(J) Peak HR	Mean difference (I-J)	Std. Error	Sig.[a]
Control	Proximal	1.70	0.84	.161
	Distal	-2.22*	0.86	.049
Proximal	Control	-1.70	0.84	.161
	Distal	-3.93*	0.76	<.001
Distal	Control	2.22*	0.86	.049
	Proximal	3.93*	0.76	<.001

Based on estimated marginal means
a. Adjustment for multiple comparisons: Bonferroni.
*. The mean difference is significant at the .05 level.

The analysis of mean peak heart rates by condition and the position of that trial in any volunteer's participation seems to further reinforce that effort was not related to trial order. Overall, the mean peak HRs are high considering that the average age of the participants was 41 years. The generally accepted maximum HR is 220 minus age (Tanaka *et al*., 2001; Robergs and Landwehr, 2002) meaning that the mean maximum heart rate for this group would be 179 beats per minute. The percentage of this mean maximum reached was 92.37%

indicating that those taking part were working hard (Control 92%, Proximal 91.5%, Distal 93.6%). This provides confidence that the participants did indeed attempt to paddle as fast as possible down the course as instructed, and that any differences appear to be as a result of the trial conditions rather than trial order.

6.8 Qualitative statistics

The self-scores, preferences and feedback from each participant were collated and are presented below.

6.8.1 Self-scores

At the end of each trial run participants were asked to provide a self-score between 0 and 100 based on their view of their own performance. They were informed that they could use the score from their first trial as a benchmark around which they could provide scores in later runs. This gave a clear indication of how they believed each performance compared and therefore the impact each condition had. The descriptive analysis is below. The full data set can be found in Appendix 3.7.

Table 6.6 Descriptive statistics for wild water racers' self-scores

Self-score	Number	Minimum	Maximum	Mean	Std. Deviation
Control	27	42	90	68.1	12.72
Proximal	27	40	95	65.7	13.37
Distal	27	30	95	67.7	15.94

Table 6.6 indicates the participants believed that the control condition conferred the maximum performance benefit. This belief does not correlate with the timed performance data and suggests that performers may find it difficult to ascertain the training and performance conditions which are most effective for them. It also provides confidence that there were no impacts on the data as a result of participant effects such as Halo and Hawthorne and that they were 'blind' to the purpose of the testing. The complete self-score data can be found in Appendix 3.7.

6.8.2 Participant preferred condition

At the end of their participation, each volunteer was asked to place the four runs into a rank order and to provide reasons why. They scored each either 1 (most preferred), 2, 3 or 4 (least preferred). The pre-test was included so as to not identify it as different from the experimental conditions and to ensure that the protocols were the same for all four runs down the course. Table 6.7 shows the summary data. The full data set can be found in Appendix 3.8.

Table 6.7 Wild water racer condition preferences

Condition	Number	Min	Max	Modal score (number)	Mean	Std. deviation
Pre-Test	27	1	4	3 (16)	3.04	.81
Control	27	1	4	1 (8)	2.37	1.15
Proximal	27	1	4	1,2 (9)	2.26	1.20
Distal	27	1	4	2 (9)	2.33	1.18

Table 6.7 indicates that there was little difference between preferences for any given experimental condition though, based on the means, the proximal trial was the most preferred and the control the least (excluding the pre-test). These data do not correlate with that obtained from the self-scores or from the timed performance output. It suggests that participants may have difficulty identifying factors impacting on their performance, and/or their preferences may be led by expectations, assumptions and subjective experience of factors which they believe provide superior performance.

6.8.3 Participant comments on trial conditions

Participant comments were collected at the end of each trial run in regard to their performance and how they thought the condition affected them. A basic content analysis was conducted whereby similar comments were categorised and the total in each category added. The summary data are provided below in Table 6.8, the full analysis can be found in Appendix 3.8.

Table 6.8 Positive and negative comments on each trial condition

Condition	Positive Comments	Negative Comments
Pre-test	24	17
Control	41	29
Proximal	74	32
Distal	70	46

Table 6.8 suggests that the proximal and distal conditions were heavily favoured compared to the control condition and the pre-test. The proximal and control trials received similar levels of negative feedback though the distal condition drew the greatest number of adverse comments.

The pairwise comparisons (Table 6.2) demonstrated a significant performance benefit of a distal focus over both the proximal and control conditions. The above feedback does perhaps indicate that participants felt a benefit from a more restricted focus (whichever it was) compared to situations with greater choice. They were apparently unable to identify the difference between the relative benefits of the proximal and distal conditions. The above data do provide reassurance that the participants were also not able to discern the intent and purpose of the study and, therefore, it is unlikely that participant effects such as HALO or Hawthorne had any impact.

6.8.4 Self-selected focus during control and pre-test

To add to the discussion, each participant was asked what they thought about and concentrated on during the pre-test and control trial to see if this might assist in explaining any performance differences. Table 6.9 provides a summary of the information collected. The responses below suggest that, when not constrained, participants self-select an internal or proximal focus between 30% and 50% more frequently than a distal one. It may also indicate a degree of attentional switching. The full data set and example comments can be found in Appendix 3.9.

Table 6.9 Self-selected conscious focus in the pre-test and control trial

	Internal Conscious Focus	Proximal Conscious Focus	Distal Conscious Focus
Pre-test	42	25	31
Control Trial	14	8	16

6.9 Additional analyses

As only participants with a significant level of prior paddle-sport experience were recruited this does not seem an appropriate factor to analyse in this context. Only one person had extensive experience of having paddled wild water racers having been ranked 5th in the UK – though this did not translate into her choosing more effective self-selected focal points than those dictated in the experiment (See Appendix 3.7, Participant 10 in the full data table). Age, likewise, seems likely to be secondary to paddling competence at the time of the experiment as participants were approached on the basis of their ability.

6.10 Discussion

The results of this study demonstrate a significant main effect of conscious attentional focus on wild water racer sprinting ($p < .001$) This highly significant outcome is reinforced by a large effect size ($\eta_p^2 = .53$). The pairwise interactions (i.e. between the experimental conditions) show that distal conscious focus is significantly beneficial to performance speed relative to both a proximal focus ($p < .001$) and a no-focus control condition ($p < .001$). There was no significant interaction between the proximal and control trials (p = 1.00).

These findings augment the outcomes from the small number of previous studies examining distance effects in attentional focus research. Consistent with McNevin *et al*. (2003, stabilometer task); Bell and Hardy (2009, golf); McKay and Wulf, (2012, darts) and Porter *et al*. (2012, long jump), moving the focus point further from the participant resulted in enhanced performance. The present study extends the body of knowledge in several ways: it is one of a small number of applied studies using continuous skills (e.g. Ille *et al*. 2013; Stoate and Wulf, 2011) though, uniquely, this research project was conducted using a complex open skill – until now continuous skill work has utilised closed skills exclusively (e.g. Freudenheim *et al*., 2010, swimming). In common with the other studies in this thesis (Chapters 4 and 5), though novel in the field of attentional focus research, a large and challenging piece of apparatus was used: in this case a wild water racing kayak which had to be navigated down a stretch of river by the participants. Wild water racing thus provided a hitherto unstudied discipline which, to my knowledge, is completely new to any form of motor learning research. A further development, which has not previously been attempted outside of this thesis, is that an internal focus of attention was not assessed. Instead, and as with studies 1 and 2, two different external points (proximal and distal) were compared to each other as well as to a control condition in which no directed focus was provided to the participants.

The finding that a distal focus of attention confers a performance advantage when compared to a proximal focus and a no-focus control condition in an applied, open skill is important. Whilst the distal benefit found in the current work is in accord with previous studies which have included this focal point (e.g. Porter *et al*., 2010b; Wu *et al*., 2012), the outcome that a proximal (external) focus provided no performance gain relative to a control condition is unusual. Such a result is more typically found in internal focus versus no-focus interactions (e.g. Wulf and Su, 2007), whilst any form of external focus commonly generates an advantage to performance (e.g. Zachry *et al*., 2005), learning (e.g. Wulf, 1998) and transfer (e.g. Totsika and Wulf, 2003; Liu *et al.*, 2005) irrespective of activity and population. This external focus effect is also not limited by when it is applied, as studies have shown that both instructions provided in advance of activity (as in the current work) and those imparted between trials as feedback (e.g. Wulf *et al*., 2002), demonstrate the same benefits.

In Study 1 (Chapter 4) and Study 2 (Chapter 5) the concept of an internal – proximal focus effect alignment was advanced to explain findings in which the proximal focus outcome matches that expected from an internal focus. The hypothesis put forward suggests that in activities and situations in which the performer and their equipment could be considered conjoined, consciously concentrating on the equipment is akin to focusing on the body. Previous studies in which participants have thrown or struck equipment have not shown the interaction suggested (e.g. Lohse *et al*., 2011, darts; Zarghami *et al*., 2012, discus), nor would it be predicted under this novel theory. Other research has involved participants using apparatus to strike or control a further object (e.g. Ehrlenspiel *et al*., 2004, billiards; An *et al*., 2013, golf); whilst such equipment could be seen as an extension of the limbs, these studies have also maintained the normal separation of effect between internal and external conscious focal points. In the present study, and in the previous two experiments, the skill investigated involved the use of very large equipment which the participant sat on or in and then propelled. In all three cases this produced no proximal focus benefit in relation to the no-focus control condition and, in Study 1 and Study 2, actually resulted in a significant proximal focus deficit.

In the previous two studies in this thesis the notion that concentrating on the equipment (the kayak) which, it could be argued, was being 'worn', made it more straightforward to make a case for the hypothesised overlap of effects. In the current study though, the proximal focus was placed on the paddle; apparatus which would more easily fit the description of an implement and limb extension (such as a golf club or billiards cue) and certainly not something that could be considered 'fitted' in the same manner as a boat, bicycle or motor vehicle. This then produces further questions as to the attentional mechanism at play: when using large apparatus (such as a kayak) does the theorised conjunction of an internal – proximal effect extend to all aspects of the equipment used – even when it is additional to the 'vehicle' and less proximal, such as in the case of a kayak paddle? Alternatively, might a focus on a piece of equipment which is held and controlled by both hands in the same way (e.g. an alternating unimanual skill such as forward paddling) somehow confer the postulated effect of making it feel as if it is conjoined with the body?

Attentional focus research into supra-postural tasks (e.g. McNevin and Wulf, 2002; Vuillerme and Nafati, 2007) has demonstrated an enhancement in the primary task outcome (e.g. boat speed in the current study) when the focus is maintained on a concurrent physical task (such as manipulating a paddle whilst kayaking), though no such benefit is evident in the present findings. This may be because the two elements of the activity are inextricably linked and therefore not regarded as separate functions; if correct, this may add weight to the notion of a quasi-internal focus created by well-fitted apparatus – this possible effect not being disturbed by moving attention to the extremities of the equipment (i.e. the paddle in the current work). As most supra-postural task studies have used unrelated skills or movements this may also suggest a possible extension to that line of research.

At present, the internal focus effect is assumed based on extensive previous work (see Wulf, 2007b and Wulf, 2013 for comprehensive reviews) though, of course, the impact of the manipulations in the current thesis' experiments may produce a different and unexpected result. The solution to these questions is elusive, though as this coincidence of proximal focus effects with the normal internal focus outcome has occurred in three consecutive studies, all using large equipment in applied, continuous skills, it clearly merits further investigation.

Any such work will necessitate the inclusion of an internal focus condition to confirm or deny the suggested overlap of effects made here.

The explanation for the significant distal focus advantage in the current study may be provided by current theories of attentional focus effects. The Constrained Action Hypothesis (Wulf *et al.*, 2001; Wulf and Lewthwaite, 2010) would predict that an internal focus would constrain a performer's subconscious control mechanisms when consciously attempting to direct movements. This would lead to a performance or learning deficit in relation to an external focus (though not necessarily a self-selected one). Such an external conscious focal point is also hypothesised to confer a performance and retention advantage in comparison to self-chosen points, as it maintains a directed focus more effectively thus redirecting attention away from conscious control of movement. This effect has been demonstrated many times and is a robust learning phenomenon (see Wulf, 2007a for a thorough overview). Assuming the proposed overlap of proximal and internal focus effects accounts for the lack of a proximal (external) benefit in the current study, the distal focus benefit would correspond with the predictions of the Constrained Action Hypothesis. This would be based on the outcome of it significantly outperforming both the no-focus condition as well as a quasi-internal focus purported to be created by the proximal focus on well fitted apparatus.

Other theories can also be consulted to elicit the reasons for the outcomes in the current study. Willingham's (1998) Control Based Learning Theory (COBALT) proposes that conscious control of motor movement, such as would occur with an internal focus (and, arguably, the proximal focus in the current studies) would result in a performance decrement relative to a no-focus or external focus situation. In the present wild water racer research, not only was there no condition which performed more poorly than the control trial, the distal focus was significantly superior. COBALT seems then, to not provide a compelling explanation for the outcomes produced. Beilock and Carr's (2001) Explicit Monitoring Hypothesis argues similarly to Willingham that a conscious (skill based) focus will undermine the subconscious and proceduralised control which competent and expert performers have acquired. In contrast to COBALT though, they believe this benefit may be reversed in novices as they deem them to have not yet attained such subliminal levels of control and, according to Beilock and Carr, individuals at this stage of development will therefore benefit from a conscious focus on the required movements of a novel skill. As the participants in the present work were all competent or expert kayakers, albeit inexperienced in a wild water racer (with the exception of one individual), an internal focus would be expected to confer a disadvantage relative to all others. As no internal focus was used it cannot be known whether this would have occurred, though the proximal trial provided neither a benefit nor a detriment relative to the control whilst the distal focus was significantly advantageous. This would not be predicted by the Explicit Monitoring Hypothesis.

A further theoretical position worth exploring is that of working memory overload. Poolton *et al.* (2006) argue that internal focus detriments, as would be explained by both Willingham's (1998) and Beilock and Carr's (2001) theories above, could also be attributed to the capacity of working memory being overstretched by having to consciously manage extra, skill related information. This would potentially result in a reduction in processing speed, and therefore response time, as the additional physical movement cues are processed. Indeed, in cases in which the amount of information to be contended with is beyond the capacity of working memory to deal with, then the performer may actually be incapable of any action whatsoever – in effect, they may 'freeze' (see Smith *et al*., 2003 for an account of working memory capacity). Kasper *et al*. (2012) point out that working memory theory is not related directly to any given direction of conscious focus, as any focus could inadvertently increase the workload to be processed. It does propose though, that any increase in information to be managed, from whatever focus source, would create a performance deficit compared to an unrestricted focus condition. In the case of the present study, no such detriment is apparent. It would appear from all the above possibilities that the Constrained Action Hypothesis (Wulf *et al*., 2001; Wulf and Lewthwaite, 2010) may offer the 'best fit' for the present study's findings, though this is reliant on the accuracy of the suggested internal – proximal effect conjunction to establish an exact match – and this, as yet, is untested.

Whilst the working memory hypothesis put forward by Poolton *et al*., (2006) may not provide an obvious explanation for the findings in the current study, working memory capacity may be more important in the type of skill used in this work – an open skill. Activities in which there are variables in the performance environment which are either partially or totally beyond the performer's control make a skill more open and externally paced. The 'openness' of any given skill is not dependent on the number of variables in the environment, rather on the variability of them and the manner in which they impact the performer. Invasion games such as rugby, basketball and hockey have as the main variable the other players – especially the opposition; so-called 'adventure sports' on the contrary, have most of their variation presented by the environment itself e.g. snow conditions, terrain, weather and, in the case of wild water racing, the highly variable medium of the river. Due to the number of ever changing factors to be sensed, processed and acted upon, open skills may place a particularly high demand on working memory capacity. As Sweller (2011) and Sweller *et al*., (2011) point out, Cognitive Load Theory explains that working memory can cope with only small amounts of discrete information, therefore the more complex the activity and the greater the number of cues requiring attention the more challenging conscious cognitive processing becomes.

Open skills require the fastest responses and the greatest level of adaptability if the performer is to act skilfully and be successful. This indicates that any additional, unnecessary loading may have a negative impact on skill and performance. To date, very few attentional focus studies have been conducted using open skills, most likely due to the logistical and methodological challenges they present, though Maddox *et al.* (1999, tennis), Caserta *et al*. (2007, tennis), Masters *et al*. (2008, table tennis) and Mullen *et al.* (2012, computer driving simulation) have all used activities which varied the performance environment during participant activity. Cognitive load on working memory may be of particular concern when the tasks or stimuli are novel to the performer and cannot be subconsciously managed. From the point of view of attentional focus research, evaluating conscious focus points which are both appropriate and which effectively contain cognitive loading, may be a worthwhile avenue of investigation.

The potential reduction in available working memory space created by open skills may exacerbate any attentional focus effects as the facility to cope with extraneous information seems much reduced. The possible increase in 'sensitivity' to additional cognitive loading may mean that the interference purported by the Constrained Action Hypothesis occurs more readily in such skills. This then may account for the particularly high level of significance attributed to the distal focus benefit in the current work as well as the apparently unconventional proximal focus outcome. In effect, a distal focus on the finish required little, if any, additional processing to take place – in fact it served to reduce the amount of information the participants had to contend with as it limited what they could concentrate on and forced them to focus on the outcome of the sprint. The proximal condition conversely, insisted that the participants consciously consider the manipulation of their paddle to best effect. This seems likely to require additional memory resources as they attempted to deliberately manage a skill previously under subconscious control. A focus on the paddle may have also created a greater distraction from the purpose of the sprint – to travel as quickly as possible down the course. This would also match previous work examining task difficulty (e.g. Landers *et al*., 2005; Weir *et al*., 2005; Wulf *et al*., 2007) which found that increasing challenge led to a more significant external focus effect.

Bearing in mind the high level of river kayaking competence within the participant group in the present study, it seems reasonable to expect that they will already have identified (either consciously or, more likely, subconsciously) an optimal focus of attention which may be difficult to surpass. It would not have been surprising had a result been produced similar to Wulf's (2008) balance experiment with the *Cirque du Soleil* acrobats in which the control condition outperformed both internal and external focuses. The fact that the distal focus proved so potent in the face of this experience and expertise is surprising, though when the focusing strategies used by the participants in the control trial are evaluated, potential reasons do become more apparent.

Following the pre-test and the no-focus control trial, the participants were asked to explain what they had considered as they sprinted down the course. As can be seen in Table 6.9, the responses indicate that self-selected focuses varied widely. Interestingly, in the pre-test (which was not an experimental condition) 98 focal points were recorded compared to only 38 after the control run. This may be due to the constraining influence of the visual control point used in all experimental trials as opposed to the unconfined and naturalistic pre-test. In both these sprints though, a large percentage of the focal points used were either internal (on the body) or proximal (on the equipment). In the pre-test this amounted to 68.4% and in the no-focus trial 57.9%. These figures do leave a large number of responses being of a distal focus nature – which is very different to the complete absence of this focus in Study 1. Whilst it is possible this is caused by a cultural difference between the USA and UK in paddle-sport learning and teaching strategies (which my experience has not detected), it seems more likely that in an open skill, performers are compelled to attend to the rapidly changing environment in order to make timely and effective decisions. Notwithstanding these inter-study differences, the fact such a large percentage of participant focus choices in the current work were internal or proximal, perhaps explains why they were unable to perform more effectively in the control condition.

The Constrained Action Hypothesis would predict that any internal focus would interfere with the participants' ability to subconsciously control their movements and would thus hinder their performance. If the proximal – internal conjunction previously discussed has a similar effect as suggested, then this would only add to the constraint. An additional reason why the no-focus performances may have been undermined is that the participants frequently identified multiple different focus points (from all three types available) which they had used during the no-focus condition. This suggests that they were switching attention between competing cues and constantly monitoring the environment so that they could respond appropriately. Whilst this may be expected in an open skill situation, the fact that the distal focus, in which attentional switching was curtailed, was significantly more effective that the other conditions, suggests that performers of this level of expertise do not need to monitor and switch in the manner which was observed in the present study. It also seems likely that the additional processing required to contend with multiple sources of information in a fast-paced open skill, acted to restrict the participants in the manner explained by the Constrained Action Hypothesis.

As new activities are experienced and skills are developed it seems that constantly scanning the environment so as to be able to respond appropriately is both necessary and beneficial. It may also be, based on the distal focus advantage found in the current work, that there are situations in which it is unnecessary - and such switching perhaps acts to hinder performance. Whilst La Delfa *et al*. (2013) explain that when performers are required to respond to a cue this generates a faster reaction and movement time than when they self-initiate the action without a stimulus – the so-called 'Gunfighter Paradigm', this only works for the initial segment of a complex sequence as may be found in a ongoing open skill (Welchman *et al*., 2010; Pinto *et al*., 2011). Fairbrother and Brueckner (2008) highlight the research which demonstrates a 'switch cost' to reaction time when multiple cues compete for attention. This seems likely to supersede the 'Gunslinger Effect' in any form of extended activity – such as the task in the current study. Mounts and Tomaselli (2004) explain that spatially proximal factors compete for shared attentional resources thus slowing down identification. The more salient and abrupt the 'flanking competition' for attention, the more the identification of the main stimulus is hindered. The monitoring strategy acquired during skill development may therefore be less effective than a directed, distal focus which is outcome driven. Such a strategy may also restrict extraneous conscious processing in continuous open skill activities in which the competition for limited attentional resources is high.

As the phenomenon most, if not all, vehicle drivers have experienced demonstrates: of travelling a distance on a road without any conscious awareness of having controlled or even accomplished that; our subconscious control mechanisms are very effective. If these findings are borne out by further open skill studies, then the implications for teaching and learning will be to encourage a more directed and distal focus. At what point in skill development attentional switching may become less beneficial will also need to be investigated; this may highlight differences in attentional advice between novices and competent individuals in open skill situations, such that the distal focus advocated to both may become increasingly defined as environmental monitoring becomes subconsciously controlled.

As well as providing information on the focuses used during the control condition and pre-test, the participants also supplied a self-score as a subjective measure of their own performance immediately after each condition. They also commented on how they felt each condition affected them and whether they found it beneficial or detrimental. At the end of the practical testing each person was further asked to arrange the four runs into a preference order, i.e.

which condition they found most preferable to least preferred. The self-scores (Table 6.6) indicate that the control (no-focus) condition was believed to be the most effective by those taking part. The distal focus produced the second highest self-scores with the proximal focus in third place. These means do not reflect the actual performance times and suggest that it is very difficult for individual athletes to accurately gauge their outcomes. Examining the feedback on each trial from the participants in the present study (Table 6.8), it is clear that the greatest number of positive comments were attributed to the proximal condition which had slightly more than the distal trial. Interestingly, the distal trial drew by far the most negative remarks which, when the experience and expertise of the participants is coupled to the open skill being attempted, seems somewhat surprising. As in studies 1 and 2, the participants in the present work were unable to identify which condition was most advantageous for them.

The order of condition preference (Table 6.7) demonstrates that there was very little difference between the experimental conditions in terms of which were most liked. The mean scores indicate that the proximal trial was the most preferred with the control trial the least. This further highlights the difficulty performers have recognising effective methods – to the point where they contradict themselves in their evaluation. Whilst their scores could have been based on factors other than speed, going as fast as possible was the whole point of the exercise so should have played a large part in participant analysis.

The distal focus advantage found in the present work has been explained using current theoretical positions – with additional hypothetical possibilities advanced to augment them. It is possible of course, that other factors may be implicated in these results: the methodology is the most likely source of such differences. Due to the nature of the applied open skill being used in the current study, the difficulties of experimental control were significantly increased. One of the main benefits of conducting research in a laboratory setting is the ease with which variables can be managed – as work moves further from this context the more difficult such control becomes. This wild water racer study may well represent the most challenging environment ever considered for attentional focus research.

As with studies 1 and 2 (Chapters 4 and 5), every effort was made to identify and control potentially confounding variables: trial order, information, fatigue effects, training effects, modelling, potential distractions, equipment and so forth were all well managed. A development in the current research, based on the experience gained from the previous two studies, was the method of checking for trial order effects. Previously, the approach adopted involved using all six available trial orders (3x2x1) and then assumed this counterbalancing would prevent any ordering effect. In the wild water racer study a Latin Squares design was incorporated in which only three of the possible six order combinations were used (see Field and Hole, 2003, p.84 for a full explanation of this method). This ensured sufficiently large numbers of participants in each order (9) so that a statistical analysis could be conducted to more effectively check for any differences. Table 6.3 shows that there were no significant benefits to performance of any particular condition order (all *p* values > .05).

The two main issues which may have produced different situations within and between trials are the instructions used and the environmental conditions experienced. The instruction issue is generic to all three studies and will be discussed in the Chapter 7, a more pressing and specific challenge in the current study was to effectively control the environmental variables. Previous attempts to conduct research in an open skill context had foundered when the inconsistency of conditions made it impossible to compare like with like (see Chapter 3, section 3.10.5). In choosing wild water racing, this offered the opportunity to use a continuous skill in an environment which would remain consistent, though which offered variation which the participants would have to move through. This would therefore require them to sprint as fast as possible through a mobile and varied context. Finding an appropriately challenging venue which provided the within-participant uniformity needed, and which did not require any kayaking technique or manoeuvre other than forward paddling, was critical to this work. No open skill environment will ever be completely constant in the manner of a laboratory, though the activity and location used in this study did provide good consistency within individual participant's trials as well as very similar conditions between those taking part. Even minor changes to light, weather and water levels between participants did not alter the task they faced and certainly did not create different performance outcomes. In the same manner in which individual differences were controlled, the within-participants design used in the current research has provided the best possible consistency and control to ensure valid and reliable outcomes.

Previous attentional focus studies have found an external focus advantage to performance and retention, whilst simultaneously reporting improved (more economical) physiological measures with this focus. McNevin and Wulf (2002) found that fast Fourier transform (high frequency positional adjustments) were improved with an external focus; Radlo *et al*. (2002) reported a reduction in heart rate; Vance *et al.* (2004); Zachry *et al*. (2005) and Marchant *et al*. (2009) found much reduced electrical activity in antagonist muscles whilst Lohse *et al*. (2010) noted improved joint kinematics with an external focus (see Chapter 2, section 2.5.3 for comprehensive information on the physiological implications of a conscious attentional focus). In the present study, heart rate monitoring was utilised with the main intention of scrutinising participant recovery between sprints so a fatigue effect could be avoided. It was also used to ensure that high levels of effort were applied as requested by those taking part. The overtly positioned equipment and data collection further acted to divert attention away from the true purpose of the study in the manner of a 'red herring'. The analysis of the heart rate data shows that the higher the mean speed of any given trial the higher the peak heart rate became irrespective of trial order (see Tables 6.4 and 6.5). This provides reassurance that there were no trial order effects and no fatigue effects: the variation in heart rate is directly linked to the different experimental conditions. Based on an average maximum heart rate of 179 beats per minute (calculated as 220 beats minus mean age), the participants were working at 92% of maximum in the control condition; at 91.5% in the proximal trial and 93.6% in the distal focus sprint. In effect, they were working very hard at all times.

An interesting by-product of this monitoring was that it became possible to assess the impact of the various experimental conditions on peak heart rate. In contrast to previous studies (e.g. Mullen *et al*., 2012), the results in the present work show that a distal focus is associated with higher peak heart rate values – indirectly, going faster appears to have raised the heart rate. The statistical analysis of the peak heart rate values in the current study (Table 6.4) demonstrates a significant increase in the distal condition compared to both the control trial (p = .049) and the proximal run (p < .001). Whilst there is no significant difference between the latter two conditions (p = .161) it is interesting to note that in the no-focus control trial the peak heart rate was, on average, 1.7 beats per minute higher than in the proximal focus test for an almost identical mean paddling speed (0.11 seconds difference). Whilst this may be completely coincidental, it may also suggest that a directed external focus has an impact on heart rate. No such claims can be made on the basis of these findings though it is perhaps worthy of further study along the lines of Schücker *et al*.'s (2009) work. Any such effect could have significant consequences for athletes performing at the highest level where fractional differences may make the difference between winning and losing.

Whilst the link between higher peak heart rates and the distal condition in the current work may not seem surprising, previous studies (e.g. Wulf and Dufek, 2009; Wulf *et al*., 2010a; Lohse and Sherwood, 2012) have almost universally found that an external focus is linked to less constrained and more economical and efficient movement. In those studies though, the activities were either of an anaerobic nature or not energetic at all; in the present research there was a significant aerobic component which seems likely to have had a predominant influence whilst obscuring attentional influence on economy. Mullen *et al*.'s (2012) work did find that heart rate variability increased with a distal focus in a computer simulated car driving task relative to an internal focus, though this was as a result of state anxiety and not due to physiological stress. The present study's findings, in which significant physical effort was expended, do not mean a distal focus is uneconomical in a peak heart rate sense; rather it is not possible to know without having paddlers perform at a consistent speed under different attentional conditions. The only prior study of this type (Schücker *et al.*, 2009) found that heart rates were reduced in an external focus condition during an aerobic running task on a treadmill. It therefore seems possible that the distal focus in the present work conferred a similar advantage even though the heart rate values were raised in line with the increased speed. As with the potential impact of the proximal (external) condition, no conclusions can be drawn from the present data and it will be necessary to conduct further investigations to identify if there is actually a distal focus benefit to peak heart rate economy in an aerobic task.

In the present work no additional analyses were conducted on specific age groups or sub-groups of experience or gender. Notwithstanding the risk of a false positive finding from such an analysis, there were no clear groups apparent to assess from the study population as they were either indistinct or of insufficient number. Previous work using competent or expert volunteers has repeatedly found an external focus benefit in common with other groups (e.g. Bell and Hardy, 2009; Stoate and Wulf, 2011). The notion that high levels of experience will lead to a self-selected focus being superior to all others has only been found on rare occasions (e.g. Wulf, 2008), though well-honed technique may have had a part to play in the control condition advantage seen in Study 2. Whilst it may appear strange that experts have not optimised their focus, the findings from the present work indicate that attentional switching may be responsible for increasing cognitive load and constraining subconscious control. It has only been possible to generate this notion due to the open skill nature of the wild water racing task.

The single participant who was both an expert white water kayaker as well as an accomplished wild water racer, when questioned as part of the trial interviews, declared that she felt the finish (distal) focus had been her fastest run. On further asking whether this meant that an externally directed and applied condition was superior to the one in which she, a nationally ranked performer, had been allowed to self-select her own focus, she was somewhat nonplussed, though had little choice but to agree this was the case. On reviewing her times later it did indeed transpire that the distal condition had been her fastest run. Were such an outcome to be repeated amongst elite athletes in this and other disciplines it would have clear implications for performance and coaching. Further studies into the impact of a distal focus in elite sport may well prove fruitful in the search for a competitive edge.

6.10.1 Summary

This unique study has shown that a distal focus can be significantly beneficial to performance in an applied, continuous and open skill. The usual finding that an external (proximal) focus is superior to a control (no-focus) condition was not found in this work. The participants in the current research were all experienced and competent kayakers – many of whom kayak and canoe in the most challenging environments available, yet a directed distal focus superseded their expertise and demonstrated that even highly skilled individuals can be afforded a performance advantage with an appropriate attentional intervention.

These findings develop and extend current knowledge by using a novel activity, an experimentally challenging and unusual skill type, as well as a methodology which compared two different external focus points. Whilst the distal focus benefit is a large and highly significant effect, some of the reasons posited for this have gone beyond current theoretical explanations. In the case of the proximal (external) focus outcome in relation to the control condition, the concept of an internal – proximal focus conjunction has been advanced to account for the lack of a proximal focus benefit. This latter finding tallies with the previous two studies (Chapters 4 and 5), in that a proximal focus conferred no advantage compared to the no-focus condition and, in Studies 1 and 2, actually resulted in a significant performance disadvantage. These findings are unexpected and the explanation for them is, as yet, unclear. Further research to test, elicit and further develop the explanations suggested in the current work is required.

The present work forms part of a trio of continually evolving and progressive studies. Further work which repeats this research, or which is similar to it, should assess and ensure its validity and reliability. Prospective experiments also need to be designed to delve more deeply into the effects of attentional focus in open and continuous skills. Research into attentional switching, as seen amongst the participants in the current work, may be particularly interesting. Whilst this tactic was ineffective in relation to the distal focus in the present study, as open skill complexity increases and intermediate focal points become more critical, understanding how a more dynamic approach to attention may be most beneficial will be important. In addition to this, cross-checking the current findings against different populations (e.g. novices, elite athletes), a variety of suitable sports (e.g. cycling), a range of durations and focus distances as well as attentional effects in aerobic activities, will all enhance the current body of knowledge and permit more effective strategies to be adopted by learners, performers and coaches alike.

The findings of this wild water racing based research have immediate implications for this and other similar sports. The potency and scope of the distal advantage found here appears unlikely to be limited to kayak racing in the UK. On the contrary, it seems that these effects may be found anywhere this activity takes place or coaching is available. Furthermore, it would be extraordinary if these findings did not extend to other activities and open skills. Performers and coaches in such disciplines should consider the attentional focus they deploy and encourage. In particular, the potential benefits of a distal focus of attention should be evaluated and adopted, as to not do so may act to restrict performance.

Chapter 7

General Discussion and Concluding Comments

This thesis has examined the impact of two external conscious focal points on the performance of continuous kayaking skills. The studies have encompassed three different populations, boat types and environments as well as assessing both closed and open forms of the skill. Studies 1 and 3 found large and significant benefits to performance of a distal conscious focus, whereas in Study 2 the distal focus and no-focus control conditions were almost equally the most effective. In no case was the proximal external focus found to be beneficial in comparison to the other two trials: in studies 1 and 2 the proximal attention condition resulted in a performance detriment compared to the distal and control trials whilst in Study 3 it was not significantly different from the no-focus condition. The variations in the results have been explored in the preceding discussions (Chapters 4, 5 and 6) though it is striking that the distal focus has not been superseded at any point – even when working with the K1 racers who appeared to have a well-honed technique. On the contrary, it appears to provide a significant performance advantage to individuals of a range of competence and expertise even when that experience may be expected to have already optimised attentional focus. The results from the proximal focus trials were surprising considering the majority of previous studies have found an external focus benefit – particularly as the external point used has typically been a proximal one (e.g. McNevin and Wulf, 2002; Ford *et al*., 2005; Lohse *et al*., 2010; Carpenter *et al*., 2013).

The incentive for the present thesis was to better understand the impact of attentional focus on the performance of physical skills; the three studies conducted to extend attentional focus research have provided findings which offer both support and challenge to the current *status quo*. As the case for an external focus benefit in relation to an internal (body) focus has been well made (see Wulf, 2007a; 2007b; 2013), and based on the study conducted for a previous Masters degree (Banks, 2009), the objective of the current work was to extend investigations into the impact of distance of external focus. Specifically, understanding the interaction between the commonly studied external focus (a proximal point), and a distal focus unconnected to the equipment or immediate surroundings, was deemed to be of prime interest. The small number of previous studies conducted examining focus distance have demonstrated that a distal focus can outperform both a proximal focus (e.g. McKay and Wulf, 2012) as well as an internal one (e.g. Bell and Hardy, 2009), though most of this work had been conducted using discrete skills. This led therefore, to the present thesis considering both novel disciplines and rarely examined or completely novel skill types.

7.1 Methodological developments

The methodological approaches used in the present thesis have been fully documented and explained, though on reflection, there are some general issues which are worth highlighting for future reference. The within-participant design was effective at producing large groups to work with and the counterbalancing ensured parity between the independent variable conditions.

This approach does, however, prevent any assessment of retention and transferability as the participants have been exposed to all conditions in the performance trials. It would be helpful in future work, if sufficient numbers of participants and researchers are available and the challenging logistics can be managed, to evaluate the persistence and adaptability of the performance benefits found in the present thesis under a distal external focus.

Whilst the participants in studies 1 and 3 were volunteers in the true sense, this was not the case in Study 2. This led to some disquiet over motivation and effort which was exacerbated by the simultaneous attendance of three or four participants who were rotated through the protocols during any one session. In future these concerns need to be reduced or eradicated by increased vigilance to ensure motivated volunteers are enrolled and then become the sole focus for the period of their trials. This is particularly important when work into such experimentally challenging activities is conducted - as controlling variables is sufficiently demanding without introducing additional potential concerns.

An additional or alternative explanation for the results in the three studies in this thesis, particularly the proximal focus outcomes, could be that an aspect of the methodology somehow produced a situation in which this may occur. This was considered carefully and all decisions rigorously reviewed; it does seem that all the key variables were identified and well controlled, measurement was accurate, consistency across trials and participants was of a high order and the participants' beliefs over condition preference and effectiveness did not affect their paddling speed. The only possible question remaining is that concerning the instructions. Whilst the quantity of information was controlled and minimised, and does not appear to have had any effect, the content was, debatably, different for the proximal and distal conditions. Obviously, it is necessary to provide distinct focal points to enable comparisons, though in this study, it could be argued that they are qualitatively different. In the distal trial the participants were asked to focus on the finish and, as there was no physical finish present, this was somewhat abstract as they would have had to imagine or visualise reaching and crossing the line. In the proximal run the focus was placed on either the boat and its stability (studies 1 and 2) or the paddle (Study 3) – clearly, there is nothing abstract about these points as they comprise significant physical objects which had to be manipulated by the participants. A case could be made therefore, that this distinction in instruction may have influenced the outcome and it is perhaps a test of a focus on an imaginary point versus a 'concrete' one.

The difference in the instructions is though, not as great as it may appear: the points used are ones which would be naturally selected in various sprinting activities, have been utilised in other sports sprinting studies (e.g. Ille *et al*, 2013), and are ones which the participants in the current studies reported focusing on in the control trials and pre-tests when they were free to choose. Neither the proximal or distal points should therefore have caused any additional processing by virtue of unfamiliarity. The argument that the two focuses required those taking part to consider a physical versus a less tangible point can be mitigated by pointing out that in both cases the points had to be imagined - as vision was controlled and not available. In removing the physical finish point it became possible to control for vision far more easily as there was nothing which could draw the eye; this was deemed a more important variable to contain as visual attention may have affected performance and obscured the impact of conscious attention alone. Thinking about a point, whether it physically exists or not, seems likely to require similar levels of cognitive effort and discipline – in fact, focusing on a more conceptual location as opposed to a physical one appears, if anything, to be more challenging and disadvantageous which would make the distal advantage found even more notable.

Without conducting further research to assess the relative influence of 'concrete', imagined or any other types of focal points, it is not possible to know whether this factor made any difference. If more work is carried out into the importance of distance, it seems likely that this will be a recurring issue as the more disparate the focal points the more different they and their associated information seem likely to become. Wulf recently highlighted (2013, p.91-92) the methodological consequences of poor instructions for trial participants. In particular, she cites studies which have overwhelmed participants with complex and lengthy directions (e.g. Casteneda and Gray, 2007, Lawrence *et al*., 2011), ones in which the instructions are ambiguous and therefore cannot be relied upon to generate the focus or activity desired (e.g. Perkins-Ceccato *et al*., 2003; Canning, 2005), and ones which are so dissimilar that they are not comparing like with like (e.g. Zentgraf and Munzert, 2009). Considering all of the controls put in place in the current study it does seem that the distinction in instructions is minor, would not invoke admonition by Wulf and is unlikely to have compromised the outcome. The directions used were in fact short, straightforward, distinct and unambiguous (Appendices 1.6, 2.4, 3.6); they clearly generated the desired focus. It was also the case that the focus points most favoured (and often believed to be quicker) by the participants were, in actuality, significantly less effective than the distal focus (see Table 4.6). Whilst the only sure way to control instructions is to make them as similar as possible in every way, whether or not this could have been better achieved in the present studies, the relative performance merits of the two directed focus points used stand in stark contrast to one another in all three cases. Other applied studies, which have included an assessment of focus distance, have also used instructions which are qualitatively distinct though this seems not to have affected the outcomes of the studies (e.g. Bell and Hardy, 2009; McKay and Wulf, 2012). It does appear therefore, that the performance outcomes recorded can confidently be attributed to the conscious attentional focus points deployed in the trials.

7.2 Theoretical issues

In Chapter 2 the pertinent theoretical positions were outlined and it was explained that there is no current, universally accepted explanation for the attentional focus effects found by academic research. Willingham's (1998) Control Based Learning Theory (COBALT) argued that a conscious focus on movement mechanics would create a performance deficiency in relation to both a no-focus and external focus condition. This was extended by Beilock and Carr (2001) in their Explicit Monitoring Hypothesis by claiming that an internal conscious focus would be beneficial for novices as they need to concentrate on and understand movement fundamentals. In contrast, Beilock and Carr argue that the same conscious focus would be disruptive to skilled performers as it would interfere with their proceduralised, subconscious control mechanisms. Several of the experiments conducted by Beilock and her colleagues (Beilock *et al*., 2002; Beilock *et al*., 2004; Beilock and Gray, 2012) concentrated on distracting learners and performers from their primary task with both task relevant and task irrelevant cues and then measuring the impact. They found that novices were less disadvantaged than competent participants who were being distracted from their subliminally managed method.

The criticism of the Explicit Monitoring Hypothesis is that it is not a pure examination of attentional focus which might elicit the relative merits of an internal or external focus on a particular skill rather than a performer's resilience to distraction or dual task load. Wulf *et al*. (2001) and Wulf and Lewthwaite (2010) believe that their Constrained Action Hypothesis provides a more appropriate and robust theoretical framework arguing that an internal focus on the body will show no significant benefit relative to a no-focus condition, whilst an external focus will confer a performance, retention and transfer advantage. They claim this will be because our ability to subconsciously and dynamically self-organise motor movement is constrained by competition and conflict with conscious cognitive control. Critically, they do not believe it is necessary for novices to have explicit knowledge of a skill or technique to be able to perform, learn or adapt it. Whilst there may often be technical elements of a skill and its associated movement patterns which might require explanation - as they are not or cannot be discovered by the learner, Wulf and her colleagues contend that in reducing conscious cognitive control of bodily movements and instead concentrating on points external to the body, performance will be unconstrained and subconscious control and learning will be enhanced. The majority of rigorously designed attentional focus work published to date supports this notion of an external focus benefit in relation to both an internal focus and a no-focus condition (Zachry *et al*., 2005; Lohse *et al*., 2011, Duke *et al*., 2011). This external focus advantage crosses boundaries of age, experience and expertise in a manner not expected under COBALT and the Explicit Monitoring Hypothesis.

The studies in the current thesis have not provided an exact fit with any of the above theoretical stances. In all three experiments (Chapters 4, 5 and 6) proximal external attention produced either no benefit relative to the undirected focus condition (Study 3) or was comparatively detrimental (studies 1 and 2). These findings do not match the external focus benefit typically reported; instead they mirror, or are even more disadvantageous, than the outcomes related to an internal focus on the body (e.g. Caserta *et al*., 2007; Lohse *et al*., 2010; Duke *et al*., 2011; Wulf *et al*., 1998). As no internal focus condition was used in any of the studies in the present thesis, it is not possible to know whether that would have generated different results to the proximal focus; this will be worthy of future study. However, in an attempt to explain the current findings a conjoined apparatus hypothesis was proposed. This argues that in cases where the equipment being used is propelled by and so fitted to the participant that a (proximal external) focus on it produces similar outcomes to an internal one on the body itself. The size, fit and encompassing nature of any apparatus as well as the proximal focus distance all need to be evaluated to refine or dismiss this hypothesis. Interestingly, in the one current study (Study 3) in which the proximal focus was on an implement held by rather than fitted to the participant (i.e. on the paddle), the detriment observed was reduced compared to the other two studies in which the proximal focus was on the boat.

The significant distal focus benefits found in studies 1 and 3 have been reported in a small number of other studies assessing distance (e.g. McKay and Wulf, 2012; Bell and Hardy, 2009). To the best of my knowledge however, the present thesis contains the first experiments which have placed the distal focus so far from the participants. Even at such extended range it still provided a large and significant advantage for two groups of participants (studies 1 and 3) thereby agreeing with and augmenting previous work on focus distance (e.g. Porter *et al*., 2010b). In these cases the Constrained Action Hypothesis (in conjunction with the conjoined apparatus explanation) offers a rationale for the outcomes, as both a self-selected focus and a proximal focus appear to have restricted subconscious and efficient movement. Distal attention, on the contrary, was not bettered in any of the current studies though it did not outperform the participant-chosen focus points in Study 2. The theoretical implications of this are not yet clear as there are potential questions over participant motivation. If it transpires these concerns are baseless, then it may well be that when trained athletes are reproducing a closed skill in a continuous manner to a high degree of perfection they are using an already optimised focus. However, in Study 2, the distal focus was only fractionally different to the unrestricted focus (0.07 seconds) and was not one which the participants had used before. The fact that it did not undermine their performance does not match with the predictions of the Explicit Monitoring Hypothesis and leads to the question of exposure, i.e. if repeatedly confronted with a distal focus would even highly-trained competitors benefit as a result? Longitudinal research would therefore go some way to answering whether the Constrained Action Hypothesis or COBALT provide the best explanation for such findings.

The attentional focus effects found in the current thesis appear to be more straightforwardly explained using the Constrained Action Hypothesis (Wulf *et al*., 2001; Wulf and Lewthwaite, 2010) than other relevant theories, though it has not always provided an exact fit. If the distal and proximal focus outcomes found in the present work are demonstrated to be valid and reliable in future research and across domains, then additional theoretical work will be required to elucidate these effects.

7.3 Attentional focus in the field of motor learning

Whilst this thesis has specifically concentrated on conscious attentional focus, it is not an aspect of research which exists in isolation. The field of motor learning encompasses multiple lines of enquiry and it is important to understand whether attentional focus evidence complements other elements of study. If this is the case, might combining evidence and approach lead to more potent and effective physical skill acquisition? Do other strands of motor learning research supplement the evidence and argument for the use of an appropriate external attentional focus?

Research into interference effects, i.e. the impact of practise variety on skill acquisition, has consistently demonstrated enhanced retention and transferability of learning with the inclusion of structured interference. Based on the original psychological concept of schemas[29], Schmidt (1975) advocated the notion of discrete motor schemas which he termed generalised motor programmes. Schmidt argued that one generalised motor programme (akin to a memory schema) would encompass the variables of force, speed and timing within a single movement pattern, i.e. that altering the value of any of these factors would not require additional memory. Research demonstrated (e.g. Shea and Kohl, 1993) that even when repeating the same action in a practise situation, if the force, speed or timing were varied this led to significantly improved retention and transferability compared to having no variability of practise. Other research examined the effect of introducing interference by using a different generalised motor programme to the one being practised. This

[29] Schemas are abstract mental representations of a class of people, objects, events or situations which we may refine and develop over time with experience. Such cognitive structures were first postulated by Bartlett (1932), though it is Jean Piaget (e.g. 1932) who is perhaps best known for using the concept of schemas in his theories of child development and education.

involves alternating attempts on the skill being developed with different movement patterns to introduce, what was termed, contextual interference (see Magill and Hall, 1990; Fairweather, 2000). Again, it was discovered that the use of such varied practise schedules conferred improved retention and transferability of learning compared to the use of repetitive blocked practise. The explanation for these benefits is that having to reconstruct the mental action pattern every time the primary skill is revisited leads to greater cognitive effort and more elaborate and effective encoding in long term memory (Lee and Magill, 1983; Lee *et al*., 1994). Whilst this is not an outcome dependent on attentional focus, it seems that the two motor learning phenomena could be combined to enhance their respective effects. In essence, a skill might be practised with interference introduced as described, though with the use of an appropriate external focus included. Future research could assess the benefits of such a merging of methods.

Juxtaposed with the motor programme theorists have been those researchers who favour the dynamical systems explanation of motor skill acquisition (e.g. Newell, 2003; Kelso, 1997). Whilst this line of enquiry has not been investigated in depth in relation to attentional focus, and is rarely if ever used as a conceptual framework within which to study conscious focus effects, this does not mean that it is not worth exploring in this regard. A critical implication of a dynamical systems approach for learning and teaching is that it is most effective when the learner, the skill and the environment all interact (e.g. Shafizadeh *et al*., 2011). This indicates that an external (distal) focus on the environment is important for effective skill acquisition and brings into question the use of an internal (body) focus on physical movements and the likely attendant subdivision of techniques this engenders. From a theoretical viewpoint it also seems that a dynamical systems explanation may better mesh with current frameworks in attentional focus research – particularly as that work is extended into ever more complex skills and learning environments in which a motor programme view is undermined by the sheer volume of schemas required to be effective. With this in mind, future rigorous research examining the role of dynamical systems theory in attentional focus effects may be worth pursuing.

The effect of anxiety on motor performance has also been the subject of significant research effort spanning many years. Findings have demonstrated that whilst performance will improve with moderate levels of arousal (Eysenck and Calvo, 1992; Eysenck *et al*., 2007), when a skill is placed under sufficient pressure, not only may skill levels decline, the performer may regress to an earlier stage of development or 'choke' altogether (e.g. Pijpers *et al*., 2003, 2005; Wang *et al*., 2004). If that regression takes them to a point in their earlier learning when, for example, they may have been encouraged to focus on their body, such a relapse could have potentially serious consequences if the activity they are engaged in demands an external focus in order to be effective and safe. Beilock and Carr (2001) found that competent performers, when required to focus their attention on the movement mechanics of a skill, regressed to an earlier stage of development as their subconscious control was disrupted. Attentional focus studies have typically found enhanced performance with the use of an external conscious focus as it redirects attention from conscious control onto movement outcomes and removes competition with automatic motor control processes (Wulf, 2001). The use of appropriate attentional focus strategies in physical skill teaching and learning may then act to reduce or avoid the potential impact of anxiety on performance. It also highlights that what is taught or learned in the early stages of skill development is important, in that if anxiety may cause regression, then what was practised as a novice must still provide a robust and appropriate method under such pressure. Utilising and encouraging skill development approaches which include structured interference and an external focus of attention for example, may better prepare a learner for a wider variety of circumstances and make them more resilient to anxiety.

In regard to information provided by teachers and coaches, Masters (1992) and Masters *et al*. (1993) argued that having declarative knowledge of technique may lead learners to 'reinvest' this information and to try and monitor and control their physical movements in a conscious manner. Whilst such reinvestment varies between individuals, Masters believes that the provision of explicit knowledge of movement patterns acts to undermine implicit control processes; he therefore argued to reduce or even remove such input. An addition issue with the provision of explicit information is that in realising, or being made aware, that an activity is actually or potentially more complex or technical than was previously thought, a barrier to exploring the skill may be put in place. Furthermore, considering the amount and level of technical information which may be imparted, a belief might be embedded in learners that they must have this information in order to be competent. In effect, without conscious understanding, or at least awareness of technical factors, they may believe they cannot progress or even take part. Masters argued that initial skill acquisition unencumbered by explicit technical input allows us to explore an activity with fewer physical and psychological restraints. This in turn may result in more subconscious and dynamically organised movements with more appropriate focal points being chosen.

Supporting Master's (1992) position, Maxwell *et al*. (2000) reported longitudinal research with learners in a golf putting task, in which they were either permitted to consider the skill (explicit learning) or were prevented from doing so (implicit learning) during 3000 practise putts. Whilst the findings showed that the 'implicit' group lagged behind their 'explicit' peers throughout the practise phase, the two groups were not significantly different in a delayed retention test. In addition, Maxwell *et al*. found that the implicit learners achieved this parity of standard with significantly less declarative knowledge of the putting mechanism. The Constrained Action Hypothesis (Wulf *et al*., 2001; Wulf and Lewthwaite, 2010) is based on the premise of permitting precisely the type of implicit learning advocated by Masters and Maxwell, and of not restricting it by attempting to consciously manage physical movements. An external focus of attention appears to reduce the emphasis on declarative technical knowledge and therefore the information available to be reinvested by learners and performers.

Research conducted by Mechsner *et al*., (2001) and Mechsner (2004) on the performance of in-phase and anti-phase motor movements, discovered that when participants consciously controlled their movements, especially when under pressure, it typically resulted in an in-phase pattern. In most physical skills it is important that we can use our limbs to perform opposite (anti-phase) movements simultaneously e.g. when walking and running our arms move in opposite directions to each other and also in relation to the leg on the same side of the body. This may seem a straightforward thing to accomplish but Mechsner was able to demonstrate that when participants concentrated on the movements they were making it became difficult to maintain an anti-phase pattern. As the pressure on the skill rose, in-phase movements increased. When participants focused instead on the outcome intended, they could subconsciously produce anti-phase movement, even in complex fine motor tasks, to ensure the desired outcome. Parallel to attentional focus research, Mechsner's work has shown that focusing on the movement goal allows the body to automatically produce effective movements in a manner which seems difficult with conscious control. Maintaining an external focus of attention in physical skill learning seems likely to avoid the in-phase – anti-phase issue highlighted by Mechsner.

In summary, it would appear that attentional focus research and the approaches it encourages to physical skill acquisition are well situated in the domain of motor learning to complement other research strands. The use of an external conscious focus achieves the positive benefits of that focus and simultaneously avoids the deficits highlighted by other lines of research. It may also be that attentional focus strategies might be combined with other methods (such as variability of practise and varied practise schedules) to increase the potency of the learning environment. Far from being an isolated research field, attentional focus effects can play a crucial role in motor learning as valuable and powerful learning tools. Persuading coaches and learners to consider an approach which reduces technical input, maintains functional complexity and focuses attention externally on appropriate points may require significant inertia to be overcome. Evidence provided by motor learning research in general, by attentional focus studies particularly and by the present thesis specifically will hopefully assist in this process.

7.4 Attentional focus preferences

As well as gathering performance and physiological data in the present studies, all participants were questioned on how they felt they had performed after each trial. They were further asked what they concentrated on during pre-tests and undirected focus trials as well as what they thought of the various conditions and their order of condition preference. The findings from these elements of the research were fascinating. In the main, the participants were unable to identify which of their performances were the fastest, reported positively on the trials which were often the least effective whilst not thinking highly of the one which was most advantageous. This was particularly noticeable in Study 1 in which only two out of twenty participants correctly identified that the distal condition was their fastest run (see Appendix 2.7). Bearing in mind the high level of competence and experience within all three participant groups it is remarkable that they were so incapable of distinguishing effective conditions and best performances. Questioning indicated that they based their assessment on the approach they expected to be most advantageous (which was typically the proximal or undirected focus condition) and that this may have been as a result of training they had received or because they deemed themselves expert enough to self-select optimal points. The fact that they were so comprehensively wrong adds weight to the evidence that learner preferences should be accommodated with great caution (e.g. Coffield *et al.*, 2004a, 2004b; Pashler *et al.*, 2009, Reiner and Willingham, 2010; Geake, 2007; Howard-Jones, 2007) especially when such demonstrably powerful and robust manipulations, such as of attentional focus, seem to provide a generic benefit irrespective of population and beliefs.

7.5 Implications for motor skill learning

Wulf and Mornell (2008), in expressing concern over attentional focus strategies deployed by teachers in music education, advocate an approach whereby teachers have a full understanding of the skill at all levels but are also able to translate this knowledge and analysis into meaningful tasks based on the desired outcome. This, they argue, is quite different from the standard approach which involves a focus on fine motor control. Jänke (2006) explains that competent performers in music are believed to relate mental representations of the skill to be performed to abstract concepts which bear no apparent relationship to fine motor movements. It seems unlikely that such a subconscious strategy will be limited only to music skills. Wulf and Mornell believe that an approach which maintains an external focus on the output required, using metaphor and analogy to assist when necessary, will be superior to the present common focus on movement mechanics.

Our ability to perform complex tasks such as driving, riding a bicycle or even walking down a busy street with little declarative awareness of the minutiae of physical movement patterns or equipment control, suggests that in-depth technical knowledge is less necessary than we may commonly believe. In fact, by virtue of having such knowledge it seems that learners may refer to it in an attempt to be more effective. This 'reinvestment', as identified by Masters (1992), may mean individuals become so focused on bodily movements and equipment control, that this becomes the primary goal to the detriment of the skill and true point of the activity. Attentional focus research consistently demonstrates that a conscious focus on the body leads to deficiencies in performance relative to an external focus (e.g. Park *et al.*, 2000; McNevin and Wulf, 2002; Totsika and Wulf, 2003; Marchant *et al.*, 2011); the evidence from this thesis introduces the notion that a proximal focus may also be unhelpful and might actually be counterproductive.

The distal and proximal focus outcomes found in the current thesis should encourage an approach which identifies the most advantageous external focus point. Performers should reduce their concentration on physical movements and equipment organisation unless these factors are a clear obstruction to progress. Clearly, learners may not accurately and subconsciously self-organise movement in all cases; indeed they may need external support to protect them from harm, negative reinforcement of detrimental habits and frustrating barriers to progress. Rather than frontloading technical 'building blocks' which may be unnecessary, basing such support on an assessment of learner needs may maintain more natural complexity, reduce information load and foster more effective conscious attentional focus. A predominantly internally and proximally focused teaching and learning approach also seems likely to be used in conjunction with other less-than-ideal methods. For example, a focus on the body or equipment may well occur in tandem with the subdivision of the skill into technical components which may then be practised in a blocked and rote fashion. This may be particularly detrimental in skills in which a focus on environmental variables or desired outcomes seems critical – such as in open skills.

Research in practise scheduling (Newell, 1991), interference effects (e.g. Magill and Hall, 1990; Shea and Kohl, 1993) and attentional focus (see Wulf, 2007a, 2013) all point to a conclusion that maintaining functional complexity and realism is important to aid skilled performance, retention and transferability. The trained and intuitive beliefs of coaches, teachers and therapists (as well as of those being coached) may not always encompass these and other critical issues, or might be resistant to their use (e.g. McNevin *et al.*, 2000). It also seems to be the case that approaches to physical skill learning might not always be based on sound evidence, and that unproven methods may permeate learning environments (e.g. Greenfield, 2007; Coffield, 2004; Banks, 2011).

Whilst attentional focus evidence (and that from other motor learning fields) appears compelling, it does not yet appear to be well established in practice.

The present studies, as well as the array of attentional focus research findings amassed to date, appear to have implications for the teaching and learning of most, if not all physical skills. Whether this is in informal motor learning situations, therapeutic applications, formal physical education or discipline-specific coaching environments, understanding the effects and benefits of conscious focus manipulations is important. These effects appear to cross boundaries of populations and seem to be pertinent to all. The present work strengthens the current body of research and is particularly relevant to all those involved with the learning and coaching of continuous motor skills.

7.6 Implications for canoe-sport

The studies in this thesis all used pursuits from the same activity 'family' - that of canoe-sport. Structured coaching and learning across the full spectrum of canoeing disciplines is well established in the UK and USA with the British Canoe Union (BCU) providing personal skills awards, leadership qualifications and coaching certification in both countries. The results of the studies in this thesis imply that a distal external focus is beneficial to performance and should be considered by participants and coaches alike. This seems particularly pertinent to those specialisms in which a continuous skill element is included and when the ability to paddle quickly is required. Whilst the evidence from Study 2 showed no difference between a self-selected focus and a distal point, the fact that an unusual and restrictive attentional condition was no poorer than the control trial may mean that additional experience with a distal focus may lead to it proving advantageous for experienced racers too.

The standard approach to canoe-sport coaching has been to teach individual techniques (strokes) in isolation in a benign context. The emphasis has been, and still usually is, on the reproduction of named and fixed motor movements to a high degree of perfection. This is deemed to be of importance in providing a foundation of essential 'building blocks' which a learner can then synthesise and apply in context. The BCU's concentration on 'Body, Boat and Blade' (Ferrero, 2006, p.29) accurately indicates that the focus of attention during the acquisition of these individual techniques is internally on the body and proximally on the equipment. It is exceedingly common to see coaches encouraging learners to focus on the position and movement of their limbs and the orientation of their equipment. These coaching and learning approaches are constantly reinforced via coach training courses and published literature (e.g. Bunyan and Gibbs, 1995; Tipper, 2002; Ellis, 2004; Cameron, 2006; Ferrero, 2006; Joy, 2008; BCU, 2009; Davey, 2009, Holland, 2013, Miller, 2014). It is uncommon to find scientific evidence cited to support the methods advocated in these articles. Whilst it is clearly important that coaches can effectively analyse technical elements of skill, it is also vital that they can translate this assessment into instructions and feedback which remedy the issue they have identified whilst maintaining an optimal focus for the paddler. Of course, the emphasis on frontloaded technical information presupposes that this should take precedence over all other factors affecting skill and is imperative in the first place.

As highlighted in Chapter 1, and counter to what might be advocated by attentional focus researchers, the Stages of Learning model (Fitts, 1964; Fitts and Posner, 1967)[30] offers a further explanation why coaches and teachers may compartmentalise skills which, arguably, ought or need not be disassembled. The British Canoe Union, via its UKCC coaching awards, promotes the notion that, as a result of Fitts and Posner's theory, individuals who match with one or other of the three stages of learning identified should be taught and have learning structured commensurate with that stage. They assert that for novices in the 'cognitive stage', in which Fitts and Posner believe learners have to contend with all sensory input in a conscious cognitive manner, it is necessary to condense activities down to their component parts so that these elements may be attended to separately. The notion behind this approach being it reduces the task complexity faced by the learner, thereby permitting them the opportunity to more quickly acquire the fundamental elements of the skill. Whilst this method may well permit the rapid acquisition of isolated techniques, it may also act to hold individuals back in the 'cognitive stage' when a more complex learning environment which mirrors reality may more swiftly move them to a level of subconsciously controlled skill. Wulf (2007a, p.149) argues that we should always seek to learn and control movement at the highest

[30]It should be pointed out that Fitts' and Posner's is, perhaps, the best known of the 'stages of learning' models, though not the only one. For example Gentile (1972) has also theorised a commonly referred to structure which is quite different to that of Fitts and Posner.

cognitive level possible so that we progress to an autonomous stage of learning as quickly as is feasible. This may mean that initial acquisition of individual techniques is slowed or less precise but that the participant becomes skilful more quickly. She believes that the benefits apparent with the use of an external attentional focus, demonstrate that it is not necessary to provide learners with in-depth knowledge of movement mechanics. By providing external conscious focus points learners are able to subconsciously organise movement without conscious competition to do so.

Canoe-sports and the coaching and learning of canoeing may stand to benefit from a better understanding of the potential advantages of attentional focus manipulation. Not only does it seem that performance may be enhanced in terms of power and speed generated; by utilising an appropriate distal focus this may further act to remove the cognitive competition to control the body and equipment, thus permitting unencumbered subliminal management to take place. Focusing distally also appears likely to permit more effective decision making and improved response times as the internal and proximal focus distraction from environmental cues is much reduced. On the basis of studies 1 and 3 it also seems that a distal focus may need to be contained and that this might be more effective than disorganised attentional switching – though the optimal distal focus (or focuses) is yet to be identified.

Encouraging learners to focus internally and proximally in one discipline, such as kayaking, may not necessarily limit any disadvantage suffered to performance and learning in that activity alone. Ironically, whilst skill transferability within and beyond the activity may be hindered, the educational process utilised by learner and coach may become the default, accepted norm which may then be expected when attempting to develop other skills. In my long experience of working in the domain of physical skill acquisition, it is not at all uncommon for learners to request copious information on the movement mechanics of the skill in question, as well as then wanting to rotely repeat the movement in isolation without additional distraction. Were I to accede to such requests the resultant practise would almost invariably demand an internal or proximal focus.

7.7 Future research directions

On the basis of the current thesis several further research strands present themselves. In the first instance, conducting studies which verify or challenge the present findings will be valuable. In particular, running a further study with competitive sprint kayak (or similar) racers, whilst attending to the potential methodological issues highlighted in Study 2, should prove informative.

Due to the fact that the findings in Study 2 resulted from work with young athletes, investigations might usefully be made into any potential age or development issues related to attentional effects. Whilst previous studies evaluating focus effects on the young have shown an external focus advantage in line with studies of other populations (e.g. Thorn, 2006; Wulf *et al*. 2010b; Chiviacowsky *et al*., 2013), the participants used in Study 2, whilst young, were also experienced and competent performers in a physically and technically challenging activity. Whilst there is no current evidence which suggests age played a role in the outcomes in Study 2, it might be interesting to investigate whether there are any differences in attentional effects in skilled athletes based on their age and stage of development.

An additional factor which would stand further evaluation is that of expertise. Whilst this has not typically been demonstrated to interact with conscious attentional effects (Wulf *et al*., 2002), there is some evidence (Wulf, 2008) which indicates that expert performers may have optimised their focus to a point whereby it cannot be surpassed by a directed focus condition. In Wulf's (2008) study the elite acrobat participants were provided with laboratory balance tasks and the external focus was proximal to them. In the current studies, the tasks were of an applied nature and both proximal and distal external conditions were utilised. As in the acrobat work, studies 1 and 2 found that the participant-selected points were advantageous relative to the proximal condition though, interestingly, only in the K1 sprint kayak experiment with the youth racers (Study 2) did the distal focus not prove the most effective. This indicates that further research into the interaction between expertise and conscious focus may be useful: in particular, if performers are able to hone their technique to such a point that no directed focus is superior, in what type of skills does that occur and on what do the participants concentrate?

Further research into the consequences of attentional focus manipulations on continuous skills is also indicated by the current thesis. Trials should be conducted in different continuous activities to evaluate the generalisability of the effect in a range of contexts; the distance of the external (distal) focus should be adjusted to work towards understanding optimisation of focus and how that varies in different conditions and with different populations. Whilst the third study in the present work ventured into the experimentally challenging domain of open skills, this is clearly an arena which will benefit from further research effort. The finding that a restricted distal focus was significantly more effective than either a proximal focus or the focus points self-selected by the competent and experienced participants was of great interest. Feedback from those taking part in Study 3 made it clear that they switched their conscious attention between points they deemed important as they sprinted down the course in the control condition. Whilst this was not surprising, the fact that the fixed distal focus produced such a benefit in comparison was certainly notable. This leads to the question of how, in open skills, do performers select focus points to best effect? Whilst wild water racing is certainly an open skill, there are very many other disciplines in which the level of complexity and variety would far exceed that encountered in the current studies. It seems unlikely that activity participants will not have to constantly switch their focus in order to monitor and gather crucial information to guide their decisions and to enhance their performance; the participant comments from the present studies, particularly Study 3 in an open skill, suggest that individuals will deploy a switching conscious focus when free to do so. As found in Study 3, even though levels of experience and competence were high, this approach produced significantly poorer performances compared to a directed distal focus. This indicates the need to further investigate distal focus effects to compare the use of a single distal point with the systematic use of intermediate distal points in situations in which the performer moves through the environment. In activities in which the end point or outcome is distant, such as in endurance activities, or in sports in which performers have to change direction frequently, slalom skiing for example, will a series of controlled and directed conscious attentional points prove more effective than self-selected switching ones?

In all three studies in the present thesis, large equipment was controlled and propelled by the participants with the use of an additional, hand-held implement. The different kayaking disciplines used all required those taking part to sit fixedly in or on the craft so that any effort expended was directly translated into motion. To the best of my knowledge no prior attentional focus research has used either kayaking or large equipment of any kind, it was therefore interesting to find that the hitherto advantageous external focus – the proximal one used in the majority of previous work – became detrimental in comparison to both a distal attentional point and, in studies 1 and 2, to the no-directed-focus control condition. Had there been only a control and proximal condition used in these experiments the conclusion might have been that the competency level of the participants permitted them to self-select points at least as effective as the directed proximal point and, in some cases (studies 1 and 2), more advantageous ones. The outcomes would have been seen to mirror those found by Wulf (2008) in her *Cirque du Soleil* acrobat research. However, the inclusion of the distal attentional focus point throughout the current thesis has demonstrated that an external focus can still supersede those chosen by skilled performers – in none of the present studies was the distal focus significantly bettered by any other condition. The relative disadvantage of the proximal focus was therefore examined from a different perspective and the hypothesis advanced that, in situations in which the performer could be considered integral with the apparatus, it may be that equipment and performer become conjoined to a degree whereby the effect more commonly associated with an internal (body) focus (e.g. Landers *et al.*, 2005; Marchant *et al*., 2006) is found in this situation too.

Of further interest, in studies 1 and 2 proximal conscious attention was focused on the kayak – the equipment which, in effect, the participants were 'wearing', in Study 3 however, proximal attention was focused on the paddle. Whilst in all three experiments the proximal focus was significantly outmatched by distal attention, this only occurred in relation to the no-focus condition in studies 1 and 2. In Study 3 there was no significant difference between the proximal and control conditions indicating that when attention is placed on an implement (the paddle in this case), it is less detrimental than when placed on the fitted apparatus being controlled and propelled. Whilst the majority of previous research has demonstrated an external (proximal) focus benefit in relation to control conditions (e.g. Wulf *et al*., 1998; Wulf and Su, 2007; Lohse *et al*., 2011), this is still an interesting difference between the proximal points used across the three studies. The conjoined equipment hypothesis proposed here is therefore worthy of further investigation, though it will be important to assess any differences between a body (internal) focus and the proximal focus in such work. If this concept is supported by future investigations it will be valuable to understand at what point equipment becomes so fitted to a performer that a focus on it may demonstrate the same disadvantage as when attention is placed internally on the body. Canoe-sport offers multiple opportunities to pursue this kind of work though other activities, such as cycling and wheelchair-based sports, would provide different mediums for testing. Activities in which the attached apparatus is smaller, though still not hand-held, such as skiing and snowboarding, may offer the prospect of assessing sports in which the equipment is less enveloping though still critical to motion.

The heart rate monitoring used in studies 1 and 3 demonstrated that peak heart rates were linked to the experimental condition in use, in that they were higher in the trials producing the fastest times. In studies 1 and 3 the distal focus produced significantly faster performances than both other conditions; peak heart rates were commensurately higher in line with the additional effort apparently applied. Whilst it seems reasonable to equate greater speed with increased work, thus resulting in higher heart rate values, multiple previous studies have found increased physiological economy and efficiency under an external focus (e.g. Vance *et al.*, 2004; Zachry *et al.*, 2005; Marchant *et al.*, 2009). In the current thesis all the experimental tasks consisted of aerobic activities which were undertaken by the participants at up to 93% of mean maximum heart rates (e.g. Chapter 6, section 6.8.2). It seems possible therefore that such exertion would potentially obscure the physiological benefits a distal focus may bestow. This leads to two potential questions to be answered in future studies: does a distal focus permit performers to exert themselves more than when using self-selected, proximal and internal attentional points? If so, a distal focus may modulate perceived physical distress and potentially attenuate the internal focus generated by exertion discomfort as recorded by Tenenbaum (2001) and Hutchinson and Tenenbaum (2007). This could prove particularly useful to performers in activities demanding the application of maximum force or endurance by not only providing the distraction (from a potentially detrimental experience) deemed necessary by Morgan *et al*. (1983), it may also provide a performance advantage relative to alternative focus points. Secondly, even though peak heart rates rose in line with the faster paddling speeds in studies 1 and 3 (it was not monitored in Study 2), was there still a distal focus benefit to economy and efficiency? In order to investigate this it would be necessary to control speed, in the manner Schücker *et al*. (2009) did on their treadmill running task, whilst measuring and comparing physiological variables under different attentional conditions. This may demonstrate, in common with previous physiology outcomes in relation to an external focus (e.g. McNevin and Wulf, 2002; Radlo *et al*., 2002; Marchant *et al*., 2006), that when performance output is controlled, a distal focus might confer a relative reduction in peak heart rate and may also benefit other critical physical measures.

As well as the specific avenues of enquiry outlined above, it would also be interesting and informative to evaluate the effect of conscious focus manipulations in combination with other motor learning phenomena such as interference effects and anti-phase co-ordination. As the potential benefits of an appropriate conscious focus become more widely known, as well as continuing to refine current knowledge, prospective projects and emerging work are becoming more broadly based (e.g. Taylor, 2014, dentistry; Imam and Jarus, 2014, virtual reality learning with stroke patients; Ho *et al*., 2014, residual limb rehabilitation). Whilst the argument for effective attentional focus manipulations seems compelling, there are still many ways in which this body of work can be developed and extended to enable better understanding of conscious focus effects in motor performance and learning.

7.8 Concluding comments

The central purpose of this project was to extend attentional focus research into new skill classes and activity domains whilst assessing the impact of distance of focus. On the basis of the literature review, three linked attentional focus studies were developed which examined distance of external conscious focus in applied, continuous skills in both a closed and open skill format. These studies have broken new ground by tackling logistically and experimentally challenging motor learning situations. They have augmented current research and produced unique and informative findings which demonstrate that distance of external conscious attention may be pivotal in performance. The standard finding that an external focus is generally beneficial has not been wholly supported in the present work. Based on the outcomes of the present studies it seems that a proximal external focus may confer no performance advantage, and can actually be detrimental, relative to the use of a distal attentional point or a no-focus control condition. This may be as a result of being conjoined to apparatus which, in effect, may act as an extension of the body, thus recreating the same outcomes as are commonly seen with an internal (body) focus. It is therefore apparent that all external focus points are not equally advantageous. On the basis of the present research, it seems appropriate to conclude that a distal external focus may provide significant and sizeable performance gains in both open and closed continuous skills.

The present studies' findings conform, in part, to the Constrained Action Hypothesis (Wulf *et al*., 2001; Wulf and Lewthwaite, 2010) though there is not an exact match. In order to explain the performance deficiencies observed whilst using a proximal focus, a conjoined apparatus hypothesis was advanced to account for the internal focus-like outcomes. This proposed extension to the current theoretical framework will need to be investigated further. It is perhaps the case that the current internal – external focus dichotomy needs to be reappraised and viewed as a continuum of focus distance along which the optimal point may vary depending on the specific circumstances. Therefore, as well as working to better understand the neurological and cognitive bases for the attentional focus effects seen in this and previous research, future studies may also seek to elucidate optimal conscious focus distances in a range of motor learning situations.

The findings of the present studies offer critical indicators to physical skill learners and performers as well as their coaches, therapists and teachers. They suggest a need to review the conscious attentional points encouraged and utilised in motor learning so that contemporary evidence (such as provided in this thesis) can be brought to bear on practice. The present studies specifically suggest that external focus distance should be manipulated to best effect - there appear to be many activities in which this could be influential or even crucial. On the basis of this thesis, the apparent tendency in the teaching and coaching of motor skills to focus learner attention internally on body mechanics, or proximally on equipment or immediate surroundings, does not seem well founded. This then needs to be redressed with improved dissemination of up-to-date information on attentional focus effects.

As highlighted in this chapter, there are many avenues available to develop our understanding of conscious focus effects. I hope the present studies contribute to a more comprehensive appreciation of these phenomena, and further encourage a review of practice to encompass effective use of attentional focus strategies.

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Appendix 1

1.1 Surf ski images and information

Figure 1a Epic V10 Sport surf ski

Surf Skis are long, narrow, sit-on-top craft which are capable of the highest speeds of any paddle-sport boat with the exception of sprint kayaks (K1s). They are typically between 5 and 6m in length and approximately 0.4m wide; they are turned by means of a pedal operated rudder. A consequence of their narrow beam is that they are inherently unstable though track very well in a straight line. Due to their open-to-the-elements nature they are most popular in warm countries as a flat-water training boat and, by more competent and adventurous individuals, as ocean racing craft. Open water racing has become popular in recent years and long distance competitions are run by both the International Canoe Federation and the International Lifesaving Federation. Surf skis are only available for seated (kayaking) paddlers and a double bladed paddle is always used.

Figure 1b Surf ski at start of trial course

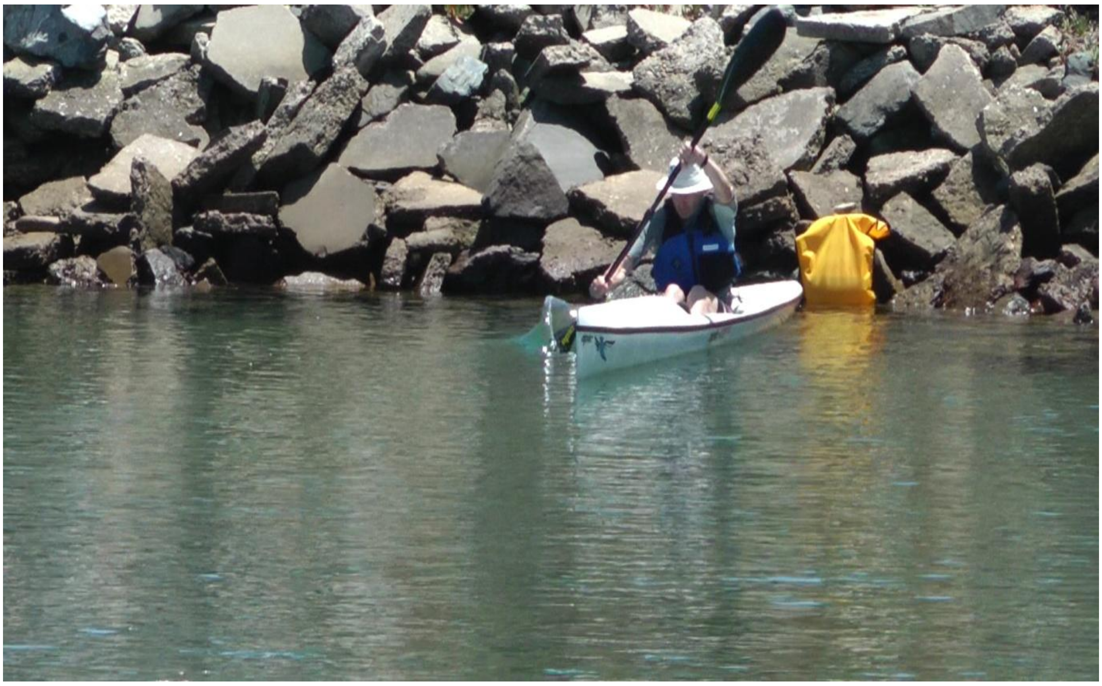

Figure 1c Surf ski on trial course

Figure 1d Surf ski at finish

1.2 Informed consent form

Stephen Banks: PhD Research Experiments

Waiver, Release of Liability and Assumption of Risk

(valid May 2011 to August 2011 inclusive)

In consideration of the research conducted by Stephen Banks and any assistants, volunteers, participants, subjects, employees and all other persons or entities acting in any capacity on his behalf (herein collectively referred to as Stephen Banks).

I hereby agree to release, indemnify and discharge Stephen Banks of liability on behalf of myself, my children, my parents, my heirs, assigns, personal representative and estate as described below with respect to Stephen Banks's research activities including practise and preparation for those activities, at any location including, though not limited to, any location where such research or preparation occurs or where equipment for those activities is placed or is in use.

I understand and hereby acknowledge that my participation in Stephen Banks's research entails risks that are known, unknown, anticipated and unanticipated, all of which could result in physical or psychological injury, paralysis, death or damage to myself, to property and/or to third parties.

I understand that these risks cannot be eliminated without jeopardising the essential and fundamental nature and quality of the activity and research. I assume these risks and release Stephen Banks from liability arising from these risks. I understand that I am hereby relinquishing certain legal rights.

I understand and acknowledge that the risks include, among other things, boat capsize, tidal conditions and currents, collision with people, objects, land, the craft I am using and other water craft as well as prolonged exposure to cold water, hypothermia and accidental drowning. Furthermore I understand that I may be exposed to sun, strong wind, cold temperatures, waves, rocks, sand, vegetation and lightning as well as poisonous, venomous, aggressive and carnivorous marine life.

I understand that Stephen Banks's research activities entail risk of physical injury including to hands, wrists, arms, shoulders, neck, back, legs, feet and head. These may occur whilst on the shore or dock, whilst getting in and out of boats and whilst paddling boats as well as due to rapidly changing and adverse weather and water conditions.

I assume those risks and release Stephen Banks from liability arising from those risks. I understand that I am hereby relinquishing certain legal rights.

I understand and acknowledge that Stephen Banks seeks safety as his first and paramount concern but that he is not infallible. He may be unaware of a participant's fitness or abilities, he may misjudge the weather the elements and/or the terrain, and he may give inadequate warnings or instructions. I also understand that the equipment being used may malfunction. I assume those risks and release Stephen Banks from liability resulting from those risks. I understand that I am hereby relinquishing certain legal rights.

I acknowledge and understand the nature and risks of sea kayak and surf ski paddling and I represent that I am qualified, in good health and in proper physical and psychological condition to participate in such physical activity and research. I agree that if at any time I deem conditions to be unsafe or I am unhappy or unwilling to continue I will immediately discontinue further participation in the activity.

I agree and promise to accept and assume all of the risks existing in this activity. My participation in this activity is purely voluntary and I elect to participate in spite of the risks.

This agreement applies to negligence alleged against Stephen Banks and/or any land or property owners involved in Stephen Banks's research: I hereby voluntarily release, forever discharge, and agree to indemnify and hold harmless Stephen Banks and any involved land and property owners from any and all claims, demands, or causes of action, which are in any way connected with my participation in this activity or my use of the equipment provided for my participation in this research, including any claims which allege negligent acts or omissions by Stephen Banks and/or land and property owners involved in this research.

Should Stephen Banks and any land or property owners involved with this research, or anyone acting on their behalf be required to incur attorney fees and costs to enforce this agreement, I agree to indemnify and hold them harmless for all such fees and costs.

I represent that I have adequate insurance to cover any injury or damage I may cause or suffer whilst participating in this research. Alternatively I agree to bear the costs of such an injury or damage myself. I agree that I assume the risk of any medical, physical or psychological condition I may have.

In the event that I file a law suit against Stephen Banks and/or any land or property owners involved in this research, I agree to do so solely in the State of California and I further agree that the substantive law of that state shall apply in that action without regard to the conflict of law rules of that state. I agree that if any portion of this agreement is found to be void or unenforceable, the remaining portions shall remain in full force and effect.

By signing this document I acknowledge that if anyone is hurt or property is damaged during my participation in this activity, I may be found by a court of law to have waived my right to maintain a law suit against Stephen Banks and/or any land or property owners involved in this research activity on the basis of any claim from which I have

released them herein. I have had sufficient opportunity to read and understand this entire document. I have read and understand it and agree to be bound by its terms.

I confirm that I am 18 years of age or older and I hereby disclose the following allergy, medical, physical and psychological conditions as well as all medication which I am prescribed or require. If I list no such conditions or medication I hereby confirm that I have no such conditions and am not in receipt of nor require any medication.

…………………………………………………………………………………………

……….……………………………………………………………………………

…………………..…………………………………………………………………

…………………………..……………………………………………………….

Participant's Signature……………………………………………………………....

Name (Print)………………………………………………………………………..

Date of Birth………………………………………………………………………..

Address (Print)……………………………………………………………………..

Telephone Numbers: Home…………………….…………..Cell………………

Email…………………………………………………………………………......

Emergency Contact Name…………………………Relationship……...............

Emergency Contact's Phone(s)…………………………………………………

1.3 Participant briefing sheet

Participant Briefing

You are agreeing to take part in practical experiments using a surf ski and must sign an informed consent form to state that you understand the risks and declare your fitness to participate.

You are taking part entirely of your own free will and may withdraw at any time. Your identity will not be revealed in any reports or publications stemming from this work.

You must have adequate insurance to cover you and any third parties in the event of injuries requiring medical attention or damage to property which occurs as a result of your participation in these activities.

You will be permitted a warm up in the boat for as long as is necessary though you are encouraged to warm up on land before participating.

You will be fitted with a heart rate monitor around your chest and a recording device on the shoulder of your pfd. Please do not tamper with this at any time during the activities.

All activities will be videoed for research purposes. This video footage will not be distributed beyond the researcher and academic staff involved with this work.

Boats, paddles and pfd will be provided by the researcher so that they are the same for everyone. If you do not fit in the provided boat the researcher will attempt to source one which is equivalent in your size. A helmet will be available if you wish to wear one, though you may use your own as fit is the most important factor in the case of this piece of equipment. You must wear appropriate clothing for kayaking which is non-restrictive. You must wear suitable footwear to protect your feet both inside the surf ski and also if you are wading – there are sting rays present so protective footwear is very important.

Your participation consists of kayaking a 75m (246 feet) straight course four separate times. That means you will be sprinting four 75m lengths. There will be a recovery period between each 75m length to allow your heart rate to return to its resting range. You must paddle all four lengths as quickly as you can. All lengths will be timed and the heart rate monitor checked at the end of each length.

The researcher will provide you with information before each length. It is critical that you make every effort to adhere to these instructions as closely as possible. The researcher will ask you questions after each length. You may be asked to complete a questionnaire.

If you become unwell or are injured you must stop immediately and alert the researcher. A First Aid kit will be available.

If you fall out of the surf ski, keep hold of the boat and your paddle and listen to instructions from the researcher.

When you have completed the tasks it is important that you do not discuss any element of the experiments with any other person. This is so that no other participants may be inadvertently forewarned about the requirements as this would invalidate their participation.

Many thanks for giving up your time to take part in this research, it is much appreciated.

S D Banks
June 2011

1.4 Surf ski testing record and trial order

Participant Number	Sex	Age	Surf Ski Experience 0 (Nil) - 10	Trial Order
1	F	56	7	D - C - P
2	M	56	7	P - D - C
3	F	67	1	C - P - D
4	F	52	8	P - C - D
5	M	61	1	C - D - P
6	F	62	0	D - P - C
7	F	25	1	D - C - P
8	M	51	2	P - D - C
9	M	65	0	C - P - D
10	F	56	0	P - C - D
11	M	57	7	C - D - P
12	M	54	0	D - P - C
13	M	70	0	D - C - P
14	F	58	0	P - D - C
15	M	67	7	C - P - D
16	F	19	1	P - C - D
17	M	62	0	C - D - P
18	F	62	1	D - P - C
19	M	62	0	D - C - P
20	F	47	8	P - D - C
21	M	69	8	C - P - D

D = Distal, C = Control, P = Proximal

1.5 Individual participant data record sheets

Subject No. Name Date R/L handed Age M/F Experience

	Trial Type (Pre-test, Control, Proximal, Distal)	Performance Order Fastest to slowest)	Start Time (Video)	Finish Time (Video)	Elapsed Time (Video)	Heart Rate (Start) bpm	Heart Rate (Peak) bpm	Self Score
TRIAL 1								
TRIAL 2								
TRIAL 3								
TRIAL 4								

	Trial Type (Pre-test, Control,	Condition Preference Order	Participant Self Score (0-100)	Comments on Preference	Reasons for Preference
TRIAL 1					
TRIAL 2					
TRIAL 3					
TRIAL 4					

1.6 Trial instructions

Pre–test

Paddle the 75 metres / 246 feet from start to finish as quickly as you can

Control

Paddle the 75 metres / 246 feet from start to finish as quickly as you can.

Look at the point identified to you.

Proximal

Paddle the 75 metres / 246 feet from start to finish as quickly as you can

Look at the point identified to you

Concentrate on your boat as requested

Distal

Paddle the 75 metres / 246 feet from start to finish as quickly as you can

Look at the point identified to you

Concentrate on the finish as requested

1.7 Surf ski combined data table

	Pre-Test					Control					Proximal					Distal				
Sub ↓	Time	HR1	HR2	Self-score	Pref ord	Time	HR1	HR2	Self-score	Pref ord	Time	HR1	HR2	Self-score	Pref ord	Time	HR1	HR2	Self-score	Pref ord
1	27.52	111	159	37	4	28.16	118	155	38	1	27.60	116	163	39	2	26.60	111	160	38	3
2	26.40	95	144	40	3	23.92	100	149	44	2	25.72	98	141	40	4	23.92	98	151	45	1
3	31.68	75	103	50	3	30.52	68	108	55	1	31.80	80	108	45	4	29.80	80	114	55	2
4	25.20	75	167	18	3	25.28	71	171	20	1	28.40	75	156	5	4	24.68	72	175	15	2
5	29.52	84	143	40	4	28.32	100	145	45	3	30.72	103	138	46	1	28.28	101	142	48	2
6	32.84	97	160	40	2	33.52	98	146	55	2	32.84	96	150	55	1	31.72	97	158	45	2
7	30.30	92	174	50	1	30.16	92	159	48	2	31.52	95	163	55	3	28.56	94	168	43	4
8	27.82	90	151	50	1	25.52	94	154	75	3	28.96	90	141	70	2	26.12	92	155	75	4
9	43.00	100	124	50	4	44.48	104	124	50	3	47.96	100	117	60	1	40.96	101	118	50	2
10	40.76	125	130	20	2	41.24	112	132	25	4	45.64	122	135	15	1	37.40	110	134	27	3
11	26.60	105	145	65	1	28.16	108	139	70	2	28.07	107	133	60	3	26.29	106	138	60	4
12	28.84	110	147	40	4	27.12	111	141	38	1	28.00	113	140	42	2	27.76	114	144	40	3
13	Participant 13 was unable to complete the trials. Their data was not including in the main analysis.																			

	Pre-Test					Control					Proximal					Distal				
Sub No.↓	Time	HR 1*	HR 2*	Self-Score	Pref ord	Time	HR 1	HR 2	Self-score	Pref ord	Time	HR 1	HR 2	Self-score	Pref ord	Time	HR1	HR 2	Self-score	Pref ord
14	32.48	103	167	15	2	31.52	99	175	14	1	32.36	111	176	13	3	31.52	105	161	7	4
15	27.36	97	139	62	3	28.56	98	143	62	2	30.40	98	132	64	1	26.36	98	144	66	4
16	31.52	86	157	50	4	31.48	85	145	70	3	31.08	84	156	75	1	29.40	84	151	73	2
17	29.04	73	120	45	4	27.19	70	125	60	3	27.51	75	124	60	1	26.13	75	133	58	2
18	35.20	86	135	60	3	32.92	87	137	67	1	37.24	86	125	63	4	32.12	87	140	63	2
19	43.20	128	160	50	4	42.74	135	149	50	3	42.08	137	147	68	1	41.68	140	161	60	2
20	29.60	80	159	70	1	28.28	90	157	73	1	28.96	86	151	65	4	28.24	90	153	65	3
21	31.46	77	103	40	4	29.92	75	102	45	2	30.52	73	104	40	3	27.52	74	109	50	1
mean	31.52		144	44.6	1.18	30.95		142	50.2	2.05	32.37		140	49	2.3	29.75		146	49.2	2.6
S Dev	5.28					5.69					6.14					4.99				
S Err	1.18					1.27					1.38					1.12				

* HR 1 = Starting heart rate in beats per minute.   HR2 = Peak heart rate in beats per minute

1.8 Surf ski participant comment analysis

Pre-test

Positive comments	**8**
Freedom to choose own focus	6
Simple	2

Example: “*Total freedom!*” Participant 14

Negative comments	**9**
Discomfiting	6
Lack of defined focus	3

Example: “*Had nothing to think about*.” Participant 1

Control

Positive comments	**33**
Easy, Comfortable, Stable	10
Liked having the visual point	10
Improved speed	6
‘Allowed me to concentrate on my technique’	4
Freedom to choose own focal point	2
Prevented a technical focus	1

Example: “*Best mental conditions to go fast*.” Participant 4.

Negative comments	**6**
Slower	3
Unstable	2
‘Distracted me from my technique’	1

Example: “*Felt less stable, seemed to lose it toward the end and felt like I was struggling*” Participant 12.

Proximal

Positive comments	**42**
Faster	23
Comfortable	9
Stable	5
Beneficial to technique	5

Example: "*Felt better, could have maintained that for a long time easily. Keeping it flat is important for boat speed*." Participant 4

Negative comments	**22**
Disruptive	12
Slower	8
Unstable	2

Example: "*Made me feel very wobbly – I couldn't do it*." Participant 3

Distal

Positive comments	**23**
Faster	11
Helpful	8
Easy	4

Example: "*More helpful, de-stressed the mechanics*" Participant 2

Negative comments	**22**
Slower	12
Difficult	5
Unhelpful	3
Unstable	2

Example: "*Seemed to slow me down – felt slower*." Participant 11.

1.9 Conscious focus choices during pre-test and control

Pre-test

Arm Cadence/Rhythm	3	Internal
Going Fast/Speed/Paddling Hard	4	Internal
Staying Upright/Stability/Balance	8	Internal
Foot Pressure/Leg Use	3	Internal
Body Rotation/Posture	2	Internal
Relaxing	1	Internal
Staying Straight/Steering	10	Proximal
Paddle Stroke/Rate	8	Proximal
Internal	21	53.8%
Proximal	18	46.2%
Distal	0	Nil
Total	**39**	

Control

Staying Upright/Stability/Balance	1	Internal
Going Fast/Speed	5	Internal
Steering/Staying Straight	6	Proximal
Paddle Use/Stroke	5	Proximal
Internal	6	35%
Proximal	11	65%
Distal	0	Nil
Total	**17**	

Appendix 2

2.1 Sprint kayak images and information

Figure 2a Sprint kayak

http://www.mar-kayaks.pt

Sprint racing kayaks are long and narrow with a rounded hull profile. Under International Canoe Federation (ICF) rules they must not exceed 5.2m though the width is not restricted; they are usually between 0.38 and 0.42m. The boats also have very little rocker (curvature of the keel) and are therefore well suited to travelling very quickly in a straight line. They are difficult to turn and are unstable – particularly whilst stationary.

In kayak sprinting the paddlers are seated in the boats and use a double bladed paddle. This should not be confused with canoe sprinting in which the paddlers kneel and use a single bladed paddle. Sprint racing is the oldest ICF discipline and current racing distances are 200m, 500m and 1000m. Competitors race in marked lanes in either solo, tandem or four person crew boats; in kayaking these are more commonly known as K1, K2 and K4. Along with kayak and canoe slalom, flat-water sprint racing is the only Olympic paddle-sport discipline.

Figure 2b Sprint kayaker at start

Figure 2c Sprint kayaker accelerates down course

Figure 2d Sprint kayaker approaches finish transit

In the centre left of this image the preceding participant can be seen returning to the holding area well clear of the kayaker sprinting towards the finish.

2.2 Trial order sheet

Testing Record Junior K1 Sprinters

Participant Number**	Gender	Age	Trial Order
E01	M	14	Distal - Control - Proximal
E02*	F	12	Proximal - Distal – Control
E03	M	14	Control - Proximal – Distal
E04	M	13	Proximal - Control – Distal
E05*	M	14	Control - Distal – Proximal
E06	M	19	Distal - Proximal - Control
E07	M	16	Distal - Control - Proximal
E08	M	16	Proximal - Distal – Control
E09	M	14	Control - Proximal – Distal
E10	F	14	Proximal - Control – Distal
E11	M	14	Control - Distal – Proximal
E12	M	16	Distal - Proximal - Control
E13	F	14	Distal - Control - Proximal
E14	F	19	Proximal - Distal – Control
E15	F	15	Control - Proximal – Distal
E16	F	13	Proximal - Control – Distal
E17	F	13	Control - Distal – Proximal
E18	F	13	Distal - Proximal - Control

* Participants 2 and 5 were insufficiently competent and consistent and their data was not included in the main analysis.

** Names have been removed to preserve anonymity.

2.3 Sprint kayak briefing sheet

Participant Briefing

These tests are part of an academic research project though the data will be made available to you and your coaches and may assist your racing performance.

You are taking part entirely of your own free will and may withdraw at any time.

Your identity will not be revealed in any reports or publications arising from this work.

All activities will be videoed for research purposes. This video footage will not be distributed beyond the researcher and academic staff involved with this work.

Your participation consists of kayaking a straight course three separate times. That means you will be paddling three sprints. There will be a recovery period between each length to allow you to recover.

You must paddle all three runs as quickly as you can. All runs will be timed. The researcher will provide you with information before each run. It is critical that you make every effort to adhere to these instructions as closely as possible.

The researcher will ask you questions after each length.

After each sprint you should paddle around in a large loop away from the course before returning to the start area. This will enable you to recover and also prevent you distracting other participants.

If you become unwell or are injured you must stop immediately and alert the researcher.

When you have completed the tasks it is important that you do not discuss any element of the tests with any other person. This is so that no other participants may be forewarned about the requirements as this may affect their performance.

S D Banks
June 2011

2.4 Trial instructions

Control

Paddle the 100m course from the start to the finish as quickly as you can.

Look at the point identified to you.

Proximal

Paddle the 100m course from the start to the finish as quickly as you can.

Look at the point identified to you.

Concentrate on your boat as requested.

Distal

Paddle the 100m course from the start to the finish as quickly as you can.

Look at the point identified to you.

Concentrate on the finish as requested.

2.5 Individual participant data record sheet

Subject No. **Name** **Date** **Handedness** **Age** **M/F**

	Trial Type (Pre-test, Control, Proximal, Distal	Performance Order Fastest to slowest)	Start Time (Video)	Finish Time (Video)	Elapsed Time (Video)	Self Score
TRIAL 1						
TRIAL 2						
TRIAL 3						

	Trial Type (Pre-test, Control, Proximal, Distal	Condition Preference Order	Participant Self Score (0-100)	Comments on Preference	Reasons for Preference
TRIAL 1					
TRIAL 2					
TRIAL 3					

2.6 Sprint kayak combined data table

	Control			Proximal			Distal		
Sub No.↓	**Time**	**Self-score**	**Pref rank**	**Time**	**Self-score**	**Pref rank**	**Time**	**Self-score**	**Pref rank**
E01	25.44	50	3rd	25.72	90	1st	25.12	70	2nd
E02*	45.40	87	1st	44.64	79	3rd	44.12	82	2nd
E03	29.72	95	1st	31.84	80	3rd	29.76	90	2nd
E04	31.92	80	2nd	33.12	70	3rd	33.12	95	1st
E05*	38.12	90	3rd	42.00	95	2nd	38.12	97	1st
E06	27.96	67	3rd	27.20	77.5	2nd	27.08	85	1st
E07	24.44	90	1st	25.88	70	3rd	24.08	80	2nd
E08	22.60	95	1st	23.20	90	3rd	22.76	92	2nd
E09	28.68	75	3rd	29.68	90	2nd	29.12	95	1st
E10	33.60	85	2nd	33.12	75	3rd	33.52	90	1st
E11	31.84	95	3rd	33.60	98	1st	31.96	97	2nd
E12	26.76	97	1st	28.50	85	2nd	26.80	90	3rd
E13	30.52	55	3rd	32.80	75	1st	29.70	65	2nd
E14	27.92	90	2nd	28.12	85	3rd	27.72	95	1st
E15	30.76	80	2nd	30.40	92	1st	33.72	80	3rd
E16	31.48	95	2nd	30.44	90	3rd	31.44	90	1st
E17	27.80	60	3rd	30.80	75	2nd	28.56	65	1st
E18	31.88	50	3rd	32.92	51	1st	30.00	49	2nd
Mean	**30.38**	**79.8**	**2.17**	**31.33**	**81.6**	**2.17**	**30.37**	**83.7**	**1.67**
Std Dev	**5.2**			**5.28**			**5.1**		

***** Participants 2 and 5 were insufficiently skilled to provide reliable data and their figures were removed before the main analysis.

2.7 Sprint kayak participant comment analysis

Control

Positive comments	8
Liked having the visual point, good focus	4
No distractions	1
Relaxed	1
Helped, was useful	1
Felt solid/stable	1

Example: "*I just focused on 'fast', there were no distractions*." Participant 7

Negative comments	5
Unstable	2
Interfered with my stroke, disruptive	2
Not as good, poorer	1

Example: "*Made me tippy*." Participant 13

Proximal

Positive comments	19
Felt good/better, liked, helpful	9
More stable	5
Concentration on technique is good	3
Felt faster	2

Example "*Faster, more stable*." Participant 9

Negative comments	10
Felt slow/slower	3
Unstable	2
Less effort (diminished effort)	1
Felt more tiring	1
Distracting	1
Disliked technical focus	1

Made me feel paranoid	1

Example: “*Thinking about boat is unstable*” Participant 8

Distal

Positive comments	**15**
Felt good, no other worries	6
Was helpful to staying straight	3
Felt fast	2
Could concentrate on going fast	2
Helped start	1
Liked accomplishment/goal	1

Example: “*Better, good goal, best of three*.” Participant 10

Negative comments	**6**
Felt slow	2
Unstable	2
Not clear (unstructured)	1
Interfered with my technique, disruptive	1

Example: “*Interfered with my technique*.” Participant 12

Appendix 3

3.1 Wild water racer images and information

Figure 3a Wild water racer

Wild water racing boats (also called white water racers) are long and narrow (4.5m x 0.6m) with a rounded hull profile. This makes them fast in a straight line though relatively unstable and difficult to turn. They are of significantly higher volume than their flat water racing counterparts and are therefore provided with greater buoyancy in the more challenging and variable conditions. This feature also reduces the pitching of the bow and stern and thereby reduces the drag which would be caused. There is an obvious, wide, flat section immediately behind the paddler which gives them a distinctive appearance and provides two functions – meeting the minimum width requirements for the class and supplying useful secondary stability.

Wild water racers exist as kayaks (seated paddler with a double bladed paddle) and canoes (kneeling paddler with a single bladed paddle), they come in both tandem and solo form. The boat in Figure 3a is a solo kayak or K1. Races are held, depending on the status of the event and competence of the paddlers, on white water between Grade 2 and Grade 4. There are two types of race: Classic, in which the competitors complete a down-river course lasting between 25 and 35 minutes, and Sprint, in which the races last for approximately 2 minutes. Study 3 used Grade 2 water and a 100m course (Figure 3b and 3c).

Figure 3b Wild water racer at start

Figure 3c Wild water racer on course

Figure 3d Wild water racer heads for the finish

3.2 Participant information sheet

Participant Briefing

You are agreeing to take part in practical experiments using a wild water racing kayak and must sign an informed consent form to state that you understand the risks and declare your fitness to participate.

You are taking part entirely of your own free will and may withdraw at any time. Your identity will not be revealed in any reports or publications stemming from this work.

You will be permitted a warm up and familiarisation in the boat though you are encouraged to gently warm up on land before participating.

You will be fitted with a heart rate monitor around your chest and a recording device on your shoulder. Please do not tamper with this at any time during the activities.

All activities will be videoed for research purposes. This video footage will not be distributed beyond the researcher and academic staff involved with this work.

Boat, paddle, buoyancy aid and spray deck will be provided by the researcher so that they are the same for everyone. If the provided equipment does not fit, the researcher will attempt to source some which is equivalent in your size or may, in the case of buoyancy aids, permit you to use yours. You should use your own helmet as fit is the most important factor in the case of this piece of equipment. You must wear this whilst kayaking. You must wear appropriate clothing for kayaking which is non-restrictive. You must wear suitable footwear to protect your feet both inside the kayak and also if you are wading.

Your participation consists of kayaking a 100m straight course four separate times. That means you will be paddling four 100m sprints. There will be a recovery period between each 100m length to allow your heart rate to return to its resting range. You must paddle all four lengths as quickly as you can. All lengths will be timed and the heart rate monitor checked at the end of each length.

The researcher will provide you with information before each length. It is critical that you make every effort to adhere to these instructions as closely as possible. The researcher will ask you questions after each length. You may be asked to complete a questionnaire.

If you become unwell or are injured you must stop immediately and alert the researcher. A First Aid kit will be available.

If you capsize in the kayak and do not roll, remove the spray deck as shown, exit the boat then keep hold of the boat and paddle and swim and/or wade back to the bank as instructed by the researcher. The researcher may assist you from the bank or by using another boat.

When you have completed the tasks it is important that you do not discuss any element of the experiments with any other person. This is so no other participants may be inadvertently forewarned about the requirements as this would invalidate their participation.

The researcher holds the highest UK qualifications available for white water kayaking as well as third party and professional indemnity insurance.

Many thanks for giving up your time to take part in this research, it is much appreciated.

S D Banks September 2012

3.3 Informed consent form

Participant consent & information form

The personal information contained on this form is confidential and would be divulged only to critical emergency or medical personnel in the event of your being incapacitated. Medical details will not be stored electronically. Please print clearly.

Full Name:..

Research Project: WW Racer...

Date of Participation:...

Address & Postcode:..

....

Phone numbers: Home...

Mobile...

Email address:...

Emergency Contact: (Name, Telephone & Relationship to you)

……………………………………..

Please list **ANY** past or present health, allergy, fitness, medical or other issues which may affect participation in this research or knowledge of which may be required by emergency services or medical staff. List any medication you use or may need. If none of the above applies please print **NONE**. (continue overleaf if necessary)

....

....

....

Informed consent

I understand that wild water kayak racing, by its very nature, has intrinsic risks and hazards associated with it. I am aware that there have been serious injuries and fatalities associated with participation in this activity. I am also aware of the real and potential hazards and risks involved with these research tests; I accept that it is impossible to protect me from them all completely.

I choose to participate in full knowledge of all relevant safety and other information pertaining to this activity and will seek further guidance from the researcher if unsure. I have provided all personal information as requested and consent to its disclosure to emergency and medical personnel in the event of my being incapacitated.

Signature:..

Print Name:...Date:..

3.4 Individual participant data record sheets

Subject No. WW   Name   Date   Handedness   Age   Sex   River Level   Experience

	Trial Type (Pre-test, Control, Proximal, Distal	Performance Order Fastest to slowest)	Start Time (Video)	Finish Time (Video)	Elapsed Time (Video)	Heart Rate (Start) bpm	Heart Rate (Peak) bpm	Self Score
TRIAL 1								
TRIAL 2								
TRIAL 3								
TRIAL 4								

	Trial Type (Pre-test, Control, Proximal, Distal	Condition Preference Order	Participant Self Score (0-100)	Comments on Preference	Reasons for Preference
TRIAL 1					
TRIAL 2					
TRIAL 3					
TRIAL 4					

3.5 Wild water racer testing record

No.	M/F	Age	WW Racer Experience (0 nil – 10 expert)	General Paddling Experience (Years/Grade)	Trial Order
WW1	M	45	0	10 / G2-3	C - P - D
WW2	M	56	1	30 / G4-5	P - D - C
WW3	M	52	0	30 / G3	D - C - P
WW4	M	25	0	10 / G2-3	C - P - D
WW5	F	37	0	15 / G2-3	P - D - C
WW6	M	43	1	25 / G2-3	D - C - P
WW7	M	39	1	30 / G4	C - P - D
WW8	M	43	0	25 / G3-4	P - D - C
WW9	M	52	0	25 / G2	D - C - P
WW10	F	39	9	20 / G3-4	C - P - D
WW11	M	56	2	35 / G2	P - D - C
WW12	M	18	0	2 / G2-3	D - C - P
WW13	M	51	0	20 / G2-3	C - P - D
WW14	F	14	0	6 / G2	P - D - C
WW15	M	55	1	30 / G3	D - C - P
WW16	M	58	0	4 / G2-3	C - P - D
WW17	M	32	0	13 / G4	P - D - C
WW18	M	52	0	6 / G2-3	D - C - P
WW19	M	38	3	15 / G3	C - P - D
WW20	F	49	0	15 / G3	P - D - C
WW21	M	29	1	9 / G3	D - C - P
WW22	M	24	0	10 / G3-4	C - P - D
WW23	M	23	0	2 / G4	P - D - C
WW24	F	20	0	3 / G3-4	D - C - P
WW25	M	55	6	40 / G3	C - P - D
WW26	M	51	3	42 / G4-5	P - D - C
WW27	F	47	1	14 / G2	D - C - P

3.6 Trial instructions

Pre-test

Paddle the 100m course from the start to the finish as quickly as you can

Control

Paddle the 100m course from the start to the finish as quickly as you can.

Look at the point identified to you

Proximal

Paddle the 100m course from the start to the finish as quickly as you can

Look at the point identified to you

Concentrate on your paddle as requested

Distal

Paddle the 100m course from the start to the finish as quickly as you can

Look at the point identified to you

Concentrate on the finish as requested

3.7 Wild water racer combined data table

	Pre-Test					Control					Proximal					Distal				
Sub No.	Time	HR1	HR2	Self-score	Pref rank	Time	HR1	HR2	Self-score	Pref rank	Time	HR1	HR2	Self-score	Pref rank	Time	HR1	HR2	Self-scoree	Pref rank
1	36.20	120	160	40	4	33.96	130	161	42	2	33.24	129	161	45	1	31.52	133	167	43	3
2	33.36	150	169	45	3	31.48	138	163	53	1	32.44	152	166	50	2	30.28	138	163	43	4
3	33.40	124	170	55	3	30.84	121	162	58	2	31.80	124	162	60	1	31.92	125	162	52	4
4	31.04	102	164	70	4	32.04	105	161	75	3	31.32	118	163	76	2	31.64	120	167	73	1
5	32.08	139	178	65	2	33.48	124	164	72	1	33.52	118	166	58	4	31.96	122	168	63	3
6	30.76	136	173	50	3	31.52	131	168	66	1	31.40	131	166	57	4	29.36	131	171	65	2
7	30.84	110	175	70	3	31.84	118	168	72	4	31.84	122	166	75	1	28.08	115	166	80	2
8	27.88	115	160	70	2	27.24	115	158	85	1	27.24	112	157	75	4	27.52	112	157	80	3
9	32.44	112	146	70	1	30.36	112	143	59	3	29.28	114	137	68	2	28.40	110	143	60	4
10	28.00	134	180	70	3	27.92	130	185	68	4	28.68	134	180	72	2	26.68	132	183	80	1
11	32.24	86	137	70	3	32.80	84	133	90	1	33.60	86	126	60	4	32.36	84	134	80	2
12	31.88	127	193	70	1	33.80	134	178	70	2	34.12	134	171	70	3	32.16	134	186	60	4
13	30.52	117	158	80	3	30.16	118	153	70	4	31.48	118	150	90	2	28.36	117	155	95	1
14	37.68	157	204	70	3	38.92	150	194	75	4	38.84	153	196	79	1	36.88	154	194	78	2
15	34.20	123	175	50	3	35.20	116	173	65	1	36.20	120	166	60	2	33.32	118	177	30	4
16	36.40	135	168	55	4	37.40	132	167	60	3	36.04	132	164	58	1	33.68	130	166	58	2

	Pre-Test					Control					Proximal					Distal				
Sub No.↓	Time	HR1 *	HR2 *	Self-scoree	Pref rank	Time	HR1	HR2	Self-scoree	Pref rank	Time	HR1	HR2	Self-scoree	Pref rank	Time	HR1	HR2	Self-scoree	Pref rank
17	28.04	123	186	80	4	27.56	123	188	90	1	29.72	124	180	75	3	27.24	120	187	82	2
18	31.04	140	171	50	3	32.88	141	164	45	2	33.36	140	162	53	1	32.36	142	166	45	4
19	26.08	136	190	52	3	26.72	140	186	58	4	27.08	138	178	56	1	25.68	138	184	66	2
20	37.28	150	180	40	4	39.68	142	167	60	3	37.40	145	178	70	2	35.52	146	177	72	1
21	28.04	127	181	85	3	28.04	125	172	90	2	28.16	125	172	95	1	27.00	125	180	82	4
22	29.08	125	181	55	3	29.76	126	174	65	2	30.24	126	168	60	4	28.80	124	169	80	1
23	35.12	116	159	65	3	35.72	110	141	80	1	35.44	111	142	40	4	35.80	110	141	75	2
24	32.04	125	180	60	3	31.56	127	175	65	4	32.16	127	170	65	1	31.52	131	170	50	2
25	29.72	135	164	40	3	28.40	132	167	60	2	28.80	129	166	50	4	26.80	127	174	80	1
26	26.53	122	166	80	4	27.76	124	152	83	3	26.60	126	161	85	2	26.92	126	163	87	1
27	35.56	127	157	75	4	36.00	124	148	63	3	35.76	125	145	72	2	35.32	121	155	70	1
mean	31.76	126	171	62.3	3.04	31.96	125	165	68.1	2.37	32.07	126	164	65.7	2.2	30.63	125	168	67.7	2.33

* HR 1 = Starting heart rate in beats per minute.   HR2 = Peak heart rate in beats per minute

3.8 Wild water racer participant comment analysis

Pre-test

Positive comments	**24**
Freedom to choose own focus	14
Allowed me to focus on my technique	3
Best Run	1
Felt faster, Good Run	1
Felt Easier	1
Felt Natural	1
Felt Powerful	1
Enjoyable	1
Cleaner through the water	1

Example: "*Allowed me to think about my line, body, rotation, using my arms well, pedal pressure...*" Participant 14

Negative comments	**17**
Lack of defined focus/structure	12
Confusing, Scrambled	2
Less powerful	1
Felt tiring	1
Didn't like having to respond	1

Example: "*Lack of focus didn't help. Trying to go fast but flitting between paddle and boat – very confusing*." Participant 1.

Control

Positive comments	**41**
Improved speed/performance	10
Easy, Comfortable, Stable	9
Could choose own focus, Space to think	8
Improved my technique	7

Prevented distractions	3
More powerful	1
The best run	1
Generated more commitment	1
Provided good reference point	1

Example: "*Had mental space to make tactical decisions rather than focus on one thing...self selecting approach felt very helpful*." Participant 2

Negative comments	**29**
Disliked fixed visual point	5
Less smooth, more splashy, poor rhythm	4
Limiting, constraining, distracting, awkward	4
Lack of purpose	3
Increased anxiety/nervousness	2
Felt unnatural, didn't gel	2
Needed more corrections	2
Less powerful, less effort	2
Slower, Slow	2
Less/No urgency/pace	1
Felt mentally harder	1
Unstable	1

Example: "*Distracted me from my line*." Participant 21.

Proximal

Positive comments	**74**
Felt efficient, rhythmic, stylish, smooth, clean	23
Liked being able to focus on my technique	11
Improved/helped my technique	7
Better/increased cadence	5
Felt more powerful	4
Felt faster, much faster	4
Easier, easier to control	4

Less work/effort	3
Liked the feedback from the boat	3
Felt like good training/development	2
Thinking of fewer things, good distraction	2
Motivating, made me want to go faster	2
Best run	1
Felt fastest	1
Felt normal	1
Built/provided confidence	1

Example: "*It improved my cadence. It all felt better and more efficient*." Participant 3.

Negative comments	**32**
Constraining, difficult, messy, distracting etc.	11
Felt slower/slow	7
Unstable, destabilising	5
Reduced effort/energy	3
Less comfortable/secure	1
Slowest/poorest	1
Lower cadence	1
Less confident	1
Lacked an outcome	1
Prevented me thinking about my technique	1

Example: "*Felt slower, felt like my line suffered. Was smooth to start with but then got worse – slower*." Participant 23

Distal

Positive comments	**70**
Felt faster/fast	11
Took mind off other things, relaxing	10
Felt better/good/surprisingly good	10
Helped with effort, motivating, most motivating	8

Felt more flowing/smooth	7
Felt more powerful/energetic/tiring	5
End goal helped	4
Enjoyable	3
Felt the best	3
More upright, good posture	2
Felt natural/comfortable	2
Stable, no wobbling	2
Higher cadence	1
Fastest	1
Less exertion, less energy	1

Example: "*Lost line slightly but felt very positive – felt good. Was surprised at how good it was – it was unexpected with this task*." Participant 13

Negative comments	**46**
Slow, slower, made me slow, lost time	10
Destabilising, unstable, less stable	9
Missed strokes, messy, splashy, less fluid	8
Felt detrimental, undermined my performance	7
Distracted me from boat/ my technique	4
Technique less good/poorer	3
Felt physically hard/harder	2
More correction needed	1
Seemed abstract/nebulous	1
Less effort	1

Example: "*Kept on working hard but felt less stable. Felt physically harder. Lost time due to instability*." Participant 5.

3.9 Conscious focus point choices in pre-test and control

Pre-test

Arm Use / Cadence	3	Internal
Going Fast/Speed/Paddling Hard	18	Internal
Staying Upright/Stability/Balance	3	Internal
Foot Pressure/Leg Use	7	Internal
Body Rotation/Posture	8	Internal
Breathing	3	Internal
Staying Straight/Steering	3	Proximal
Paddle Stroke/Rate	19	Proximal
Boat	3	Proximal
Line/Path	17	Distal
Finish	2	Distal
External Point	11	Distal
Start	1	Distal

Totals

Internal	42	42.9%
Proximal	25	25.5%
Distal	31	31.6%
Total	**98**	

Control

Body Rotation / Posture	3	Internal
Going Fast / Speed / Power / Pace	7	Internal
Arm Use / Cadence	2	Internal
Leg Use	1	Internal
Breathing	1	Internal
Paddle Use/Stroke	7	Proximal
Boat	1	Proximal
Line/Path	9	Distal

External Point	1	Distal
Start	1	Distal
Finish	4	Distal
Water Depth	1	Distal

Totals

Internal	14	36.8%
Proximal	8	21.1%
Distal	16	42.1%
Total	**38**	